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ORDOVICIAN FOSSILS FROM THE SOUTHWESTERN PART OF THE CANADIAN ARCTIC ARCHIPELAGO

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ABSTRACT—A variety of corals, gastropods, and cephalopods is described from Read and Sutton islands. A few specimens from near-by Victoria and two small adjacent islands are also considered. It is concluded that the strata which yielded these fossils are probably Upper Ordovician in age.

Two collections of fossils from Read and Sutton islands, which are just southwest of Victoria Island, were recently loaned to us by Professor C. O. Dunbar of Yale University and Professor P. S. Warren of the University of Alberta. The assemblage also includes a few specimens from two localities on Victoria Island, one from near-by Liston Island, and another from a small unnamed island about a mile northwest of Read Island. This material was collected during the summer field seasons of 1938 to 1942 by Dr. and Mrs. A. L. Washburn, Dr. Preston Cloud, and Mr. and Mrs. F. Ray Ross—Mr. Ross was the Hudson's Bay Company factor at Holman Post, Northwest Territories.

Most of the specimens are lithologically similar. They are preserved in light-gray very finely crystalline dolomite and are more or less silicified. The majority of the specimens were found *in situ*, but some of them were collected from loose boulders. A few were picked up by Eskimos.

Acknowledgment is due Drs. A. L. Washburn of The Arctic Institute of North America and Preston E. Cloud, Jr., of Harvard University for many helpful suggestions during the completion of this study and for reading and criticizing the manuscript. The accompanying photographs were retouched by Miss Mary G. Allen of Iowa City, Iowa; and the map was drawn by Mr. Howard Webster of the same city. The preparation of the report was made financially possible by the Graduate College of The State University of Iowa.

AGE

The discovery and collecting of the fossils on which this report is based give no assurance of a common origin. However, almost all of them came from within a radius of 10 miles, there is no great difference in their lithology, and the species present no incompatible associations. Altogether, we have the following forms from Read and Sutton islands (c—common; r—rare):

	Read Is.	Sutton Is.
Corals		
Favosites spp.		c
Calapoecia canadensis		c
Syringopora? conspirata		r
Halysites spp.	c	c
Arcturia sp.	c	
Streptelasma? spp.	r	c
Gastropods		
Bucania elliptica	c	c
Ophileta aff. *O. compacta*	r	
Lophospira, n. sp.	c	c
Liospira progne	c	c
Maclurina cf. *M. manitobensis*		c
Sellinema? sp.	c	
Holopea sp.	c	r
Cephalopods		
Boreoceras washburni	c	c
Boreoceras brevicameratum	c	c
Boreoceras cloudi	?	r
Boreoceras parvulum	c	
Suttonoceras rossorum		r
Gorbyoceras cf. *G. geronticum*		c
Discoceras? sp.		r
Armenoceras spp.		c

As is obvious from this list, there is a great deal of similarity in the faunas known from these two islands. However, it seems indeed peculiar that the genus *Armenoceras* is not represented in the collections made on Read Island, for it is by far the most abundant cephalopod in the assemblage from Sutton Island.

There has been a difference of opinion in regard to the significance of certain of the coral genera represented in the collections under consideration. Thus, in 1924 O'Neill (p. 26A) stated that a few fossils collected on Sutton Island had been referred to *Favosites*, *Halysites*, and *Streptelasma* by the late E. M. Kindle, and it was concluded that the containing beds are "all of Silurian age and represent a horizon which is probably about the same as that of the Lockport limestone" of the Middle Silurian (Niagaran) series. However, as noted by Ulrich (1911, p. 306) the

> late Richmond horizon . . . is characterized by an association of corals, bryozoa, and brachiopods that . . . because of the presence of the genera *Halysites*, *Heliolites*, *Calapoecia*, and *Favosites* . . . has frequently been identified as Niagaran.

It seems to us that inasmuch as we can not determine the specific affinities of most of the corals in the collections we are studying, those that belong in such long-ranging genera as *Favosites* and *Streptelasma* are of no great help insofar as fixing the precise age of the fauna is concerned. The significance of the other corals is variable. Cox (1936, p. 36), after an exhaustive study of *Calapoecia*, has concluded that the genus occurs in the Black River group but "is highly characteristic of post-Trenton and Richmond strata," and it is known to be widespread in the Arctic, having been found at numerous localities in Canada and being known also from Alaska and Siberia.

It is perhaps significant that our single specimen that is probably referable to *Syringopora* seems to be conspecific with a form known elsewhere in only the Upper Ordovician Cape Calhoun beds of northern Greenland. *Halysites*, which was formerly believed to be limited to the Silurian, is now known to occur abundantly in the Upper Ordovician of Greenland, Canada, and western United States, and it has been reported from the Middle Ordovician of the Upper Mississippi Valley. The only recorded *in situ* occurrence of *Arcturia* is also in the Upper Ordovician of northern Greenland.

Gastropods are both abundant and varied in the collections we are studying, but insofar as we have been able to ascertain, the great majority of them are not particularly helpful for a precise age determination. It should nevertheless be noted that the genus *Maclurina* is known from only the Ordovician, and it has been found to be both abundant and widespread in the Upper Ordovician of western and arctic North America. Furthermore, none of the other gastropods seems to militate against that age assignment and most of them seem to support it.

The cephalopods, likewise, may well be Upper Ordovician, but they can not be said to establish that age. Furthermore, they are not typical of the well known

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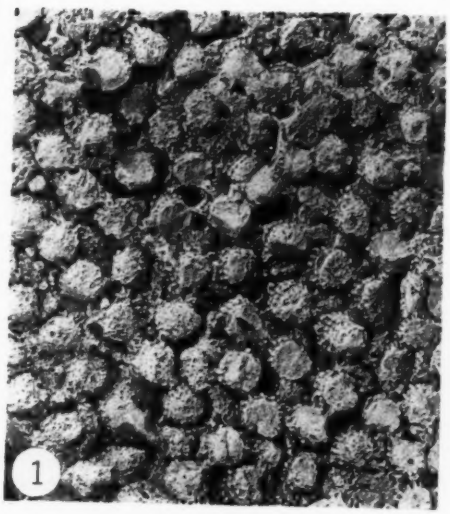
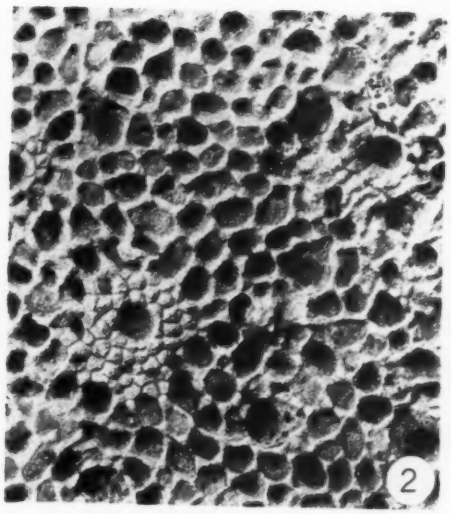
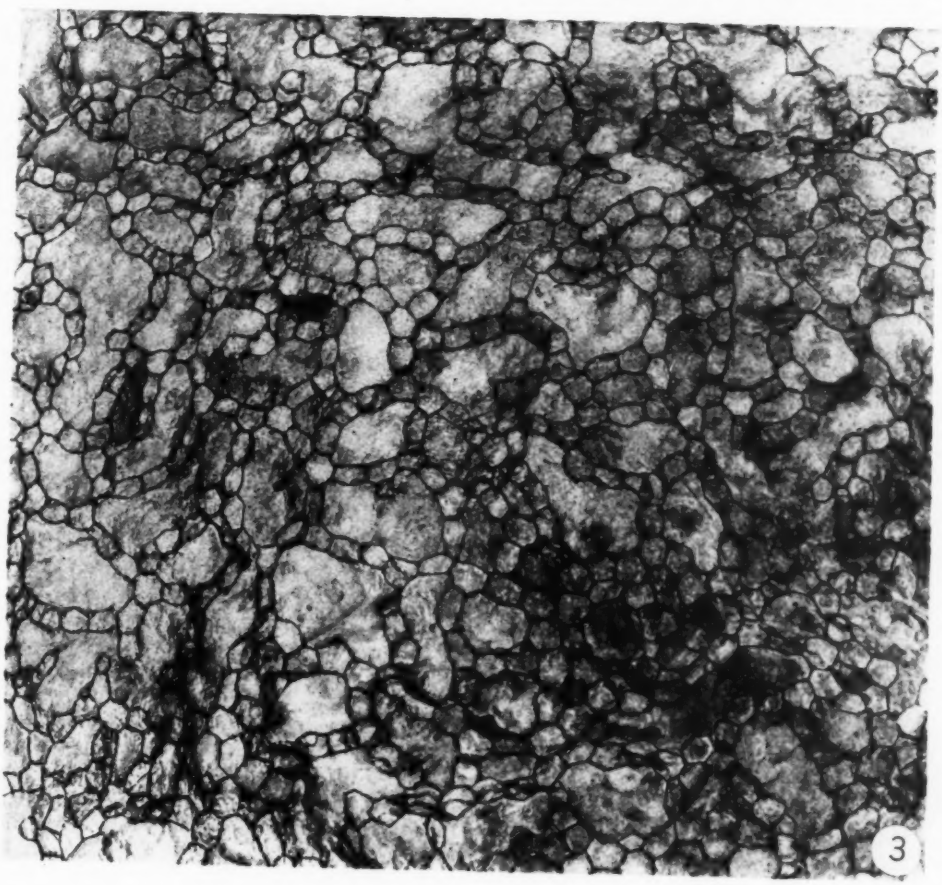
EXPLANATION OF PLATE 1

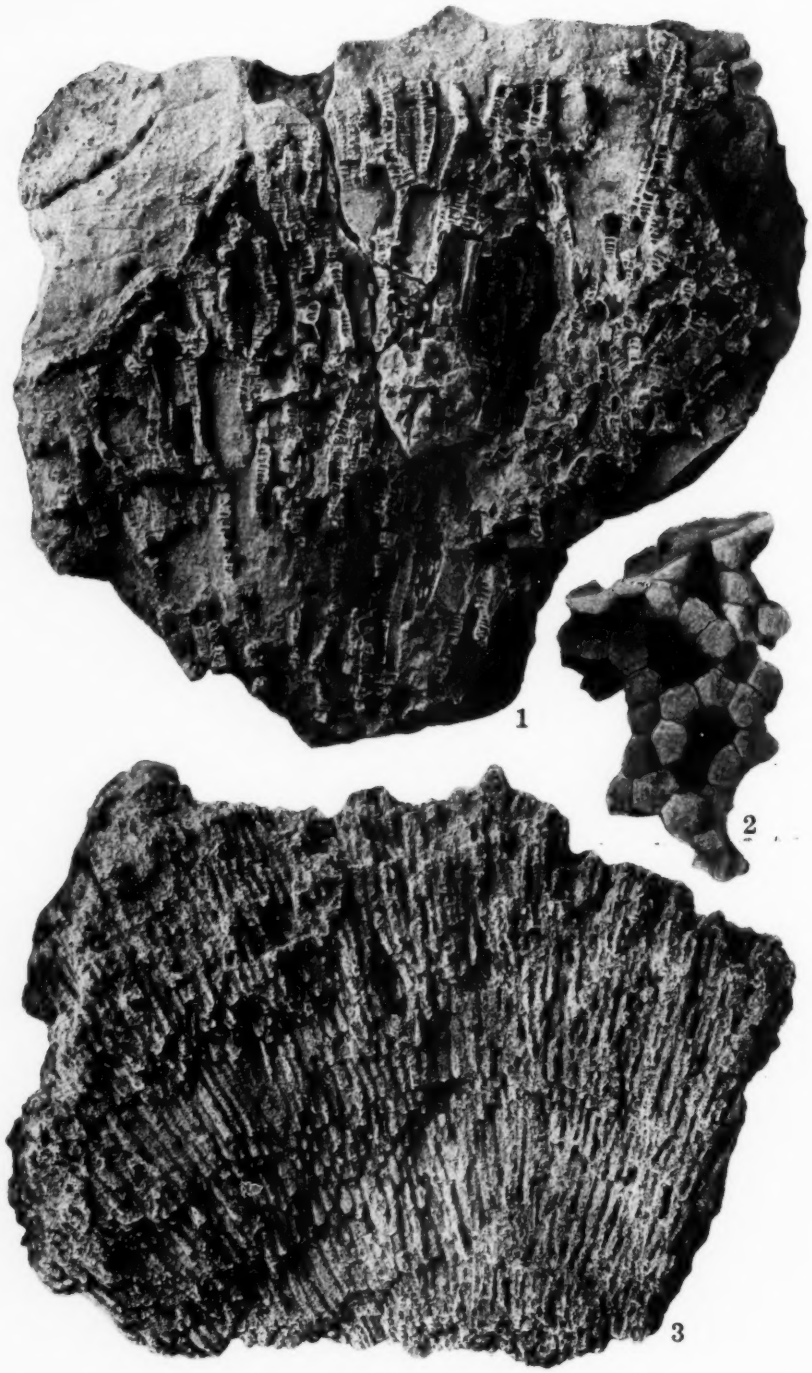
FIG. *1*—*Calapoecia canadensis* Billings. Part of an internal mold from Sutton Island, ×1½. (p. 4)
2—*Arcturia* sp. A portion of the surface of a specimen from Read Island, ×2. (p. 6)
3—*Halysites* sp. An enlargement of part of the convex surface of a well-preserved specimen from Read Island, ×4. See also figs. 1, 2, pl. 2; and fig. 9, pl. 7. (p. 5)







Miller and Youngquist, Ordovician Fossils



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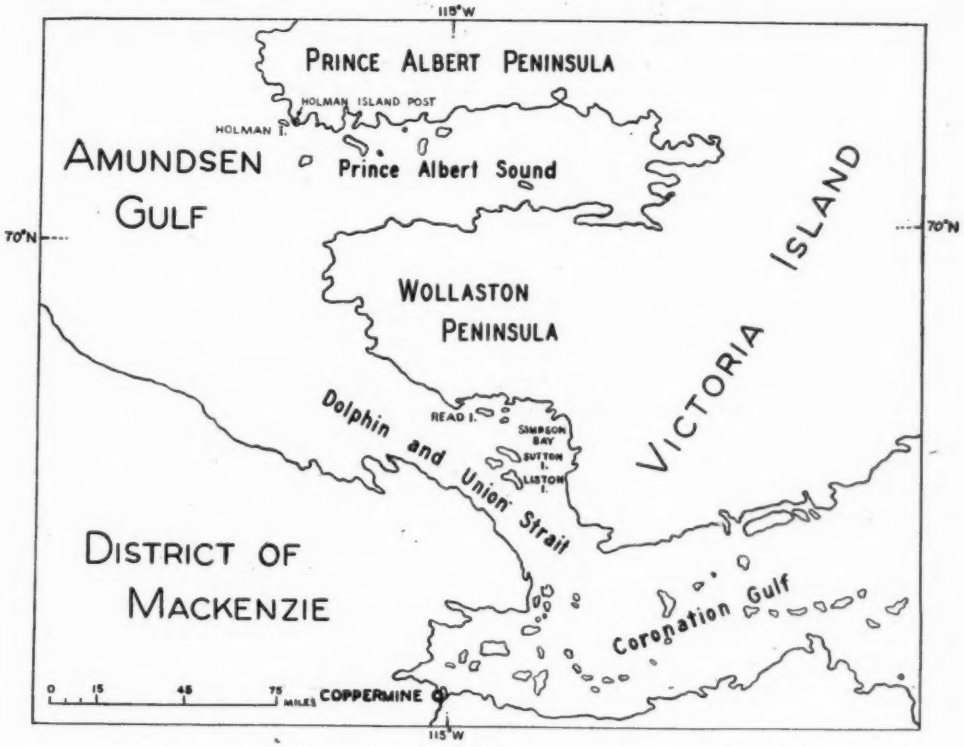


FIG. 1—Southwestern Victoria Island and adjacent regions.

Upper Ordovician nautiloid fauna that occurs in the Bighorn formation of northwestern United States, the Red River formation of Manitoba, the Cape Calhoun beds of northern Greenland, and equivalent strata at several localities in arctic Canada. The forms for which we are coining the generic term *Boreoceras* are reminiscent of the Cyrtendoceratidae which are so abundant in the Lower Ordovician but are known to range into younger Ordovician strata. The rare specimens that we are referring to *Suttonoceras*, *Spyroceras*, and *Discoceras?* can be said to resemble both Ordovician and Silurian species, and so can our representatives of *Armenoceras*, which constitute one of the most conspicuous elements in the collections from Sutton Island.

In conclusion, it seems to us that at least the great majority of the fossils we are studying from Read and Sutton islands are almost certainly Ordovician in age, but a few of them may possibly be Silurian. If, as appears quite probable, all of these forms are from one fauna, that fauna belongs in the Upper Ordovician.

From Liston Island, which is just south of Sutton Island, we have a single fossil—it was found by an Eskimo on the shore of one of the small inland lakes of the island. This

EXPLANATION OF PLATE 2

FIGS. *1, 2*—*Halysites* sp. Natural longitudinal section of much of a colony, ×1; and enlarged cross section of a small portion of the same colony, ×2⅔; from dolomite float on the north shore of Prince Albert Sound, Victoria Island. See also fig. 3, pl. 1; and fig. 9, pl. 7. (p. 5)

3—*Syringopora? conspirata* Troedsson. Natural longitudinal section of part of a colony, ×1; from Sutton Island. (p. 5)

specimen is a moderately large siphuncle that belongs in the genus *Armenoceras*. O'Neill (1924, p. 26A) states that the late E. M. Kindle identified the following forms in two collections from the eastern end of this island: crinoid stems, *Favosites* sp., *Streptelasma* cf. *S. patula*, *S.?* sp., *Diphyphyllum* cf. *D. multicaule*, *D.* sp., and *Halysites catenulatus gracilis*. This fauna, like the one Kindle studied from Sutton Island, was believed to be Silurian in age and to belong most probably in the late Middle Silurian. We share the opinion that the fossiliferous beds on Liston and Sutton islands are probably of about the same age, but we think it is much more likely that they are Upper Ordovician rather than Middle Silurian.

For the sake of completeness, it should be mentioned that in 1938 Dr. and Mrs. A. L. Washburn secured a single fossil from the float on a small island about 1 mile northwest of Read Island. This specimen (pl. 7, figs. 1, 2) is also referable to *Armenoceras*, and it is preserved in light-gray finely crystalline dolomite, as are the fossils from the near-by islands. It seems probable therefore that the containing beds are part of the same formation that yields the specimens on Read and Sutton islands.

In 1939 P. E. Cloud collected three gastropods in the southwestern part of Victoria Island just north of Read Island and about half a mile inland. These specimens came from about 30 to 35 feet above tide. Two of them are referable to *Liospira progne* and the third (pl. 3, fig. 5) belongs in an unnamed species of *Lophospira*. Both of these forms are conspecific with those that are abundant on Read and Sutton islands, and almost certainly they come from the same formation.

From the west-central part of Victoria Island, some 100 miles to the north of Read Island, Cloud secured four corals and two gastropods. These specimens came from erratic boulders of light-gray finely crystalline dolomite about 2 miles east-northeast of the Hudson's Bay Company Holman Island Post on the surface of a 500 to 600-foot trap plateau on the north shore of Prince Albert Sound. One of the corals (pl. 2, figs. 1, 2) belongs in the genus *Halysites*, whereas the other three are being referred with question to *Streptelasma*. The gastropods are doubtfully assigned to *Eccyliopterus*. This assemblage might be either Ordovician or Silurian, but tentatively we are inclined to regard it as of about the same age as that which occurs in the southwestern part of the same island and on the small islands just off the coast there.

SYSTEMATIC PALEONTOLOGY

FAVOSITES spp.

In the collections under consideration there are at least a dozen specimens that appear to be referable to the well-known genus *Favosites*. As might be expected, there is a considerable amount of variation in this assemblage, and it seems likely that more than one species is represented. However, the imperfect dolomitic preservation and the fragmental nature of most of the specimens make it difficult to determine specific affinities with a reasonable degree of accuracy. Inasmuch as the genus *Favosites* is known to range from the Ordovician to the Permian (although in North America it has not been found above the Mississippian), the value of these Arctic specimens for precise correlation is not great, and they do not seem to merit illustration.

Occurrence.—Light-colored dolomite of an east-central promontory on Sutton Island.

Repository.—Yale Peabody Museum: 17335, 17337, 17339, 17340, 17343, 17353, 17354, 17356, 17357.

CALAPOECIA CANADENSIS Billings

Plate 1, figure 1

The specimen represented by figure 1 on plate 1 and two unfigured fragments attest the presence of *Calapoecia* in the southwestern part of the Canadian Arctic Archipelago. In 1936 Cox showed that all of the known representatives of that genus belong in one species, *C. canadensis*, which he discussed in detail and synonymized.

Occurrence.—Cox concluded (p. 36) that this form appears in the Black River group but is

> highly characteristic of post-Trenton and Richmond strata, where it undergoes variation and is widespread, [being known] from Alaska eastward to Siberia (excluding the British Isles) and from Kentucky northward to Washingtonland in Northwest Greenland.

It has been recorded from numerous Arctic localities. All three of the specimens we are studying came from an east-central promontory on Sutton Island.

Repository.—Yale Peabody Museum 17345, 17348 (includes figured specimen).

SYRINGOPORA? CONSPIRATA Troedsson
Plate 2, figure 3

"*Syringopora*" *conspirata* TROEDSSON, 1928, Medd. om Grønland, Bd. 72, p. 134, pl. 43, figs. 2a–3b.

We are referring to this species a specimen that is some 105 mm., by 80 mm., by 15 mm. The general physiognomy of this specimen indicates that it represents a portion of a rather large colony. It is silicified, and, with local exceptions, its structural details are obscure.

The corallites are cylindrical in shape and are about 1 mm. in diameter. For the most part they are closely spaced, particularly in the basal portions of the specimen, and in places they appear to be in contact. Although adjacent corallites are essentially parallel, the colony as a whole is expanded radially from the base. The corallites are united at irregular intervals by small cross tubuli, which, in places, at least, are very closely spaced, being distinctly less than 1 mm. apart. The tabulae, which are more or less straight and directly transverse, are likewise closely spaced, averaging about three in a length of 1 mm.

Remarks.—In the only other known representative of this species, the holotype, the corallites are about 1½ mm. rather than 1 mm. in diameter—the taxonomic significance of this difference is questionable. As has been noted by Troedsson, the generic affinities of this species are uncertain. It resembles typical *Syringopora*, but its tabulae are not infundibuliform. *S. burlingi* Wilson of the Upper Ordovician of British Columbia [which Kirk (1927, p. 287) refers to *Calapoecia*] has larger and more widely spaced corallites, but otherwise appears to resemble this species rather closely.

Occurrence.—The holotype of this species came from the type section of the Upper Ordovician Cape Calhoun beds in northern Greenland. Our specimen is from strata presumed to be of about the same age on Sutton Island.

Hypotype.—University of Alberta, 544.

HALYSITES spp.
Plate 1, figure 3; plate 2, figures 1, 2; plate 7, figure 9

The collections being studied contain four specimens of *Halysites* that appear to represent at least three species. We are not able to refer these with a reasonable degree of certainty to any of the numerous species of the genus that are now recognized.

The small specimen illustrated by figure 9 on our plate 7 appears to represent most of a colony. It is subglobular in shape and is some 50 mm. in diameter. Its corallites are subrectangular in cross section, and their length and width average about 1½ mm. and 1 mm., respectively. Many of the intercellular spaces are quadrangular in cross section, but others are pentagonal, a few are triangular, and some are hexagonal. The "diameter" of these spaces varies considerably, but in general it ranges from about 1 mm. to about 3 mm., with a mode of some 2 mm. The tabulae are straight, or essentially so, and there are about 10 or 12 of them in a length of 5 mm. Vertical rows of spines are preserved in a few of the corallites—in cross-sectional views it can be seen that there are four or five rows of such spines on the longer side of a corallite. At least superficially, this form resembles *H. aequabilis* Teichert of the Ordovician of Iglulik and Baffin islands, but the holotype of that species has somewhat smaller corallites.

The largest of our specimens (pl. 2, figs. 1, 2) is imbedded in a light-gray fine-grained dolomitic matrix, and for the most part only a natural longitudinal section of it is available for study. However, we were able to obtain a cross section of a small portion of the colony (pl. 2, fig. 2) by dissolving the enclosing matrix in acid. The over-all length of the figured portion of the colony measures some 100 mm. and the corresponding width about the same. In cross section, the corallites are almost as wide as long, and their "diameter" averages about 1½ or 2 mm. The size and shape of the intercellular spaces appears to vary considerably, but the area of their cross section is something like three or four times that of the corallites. The tabulae are approximately straight and directly transverse, and there are about eight of them in a length of 5 mm. This form resembles the specimen from the Ordovician

of Southampton Island that Teichert (1937, pp. 55–56, pl. 7, figs. 3, 6) referred to *H. gracilis* (Hall), a species that is "widely distributed in arctic and subarctic North America."

Our best specimen is approximately circular in outline, being some 80 mm. in diameter, and it is moderately uparched to form a concavo-convex colony, the preserved portion of which averages about 10 mm. in thickness. The size, shape, and arrangement of the corallites are shown by our photograph (pl. 1, fig. 3), which represents part of the convex surface. None of the corallites is spinose, but all of them bear flat directly transverse tabulae that are about half a millimeter apart. Near the center of this specimen there is a rounded cluster of corallites (shown in the lower right quarter of pl. 1, fig. 3) that is at least superficially similar to those that occur in one of the specimens that we are referring to *Arcturia* (see pl. 1, fig. 2). The occurrence of these structures in both forms suggests that they are related, though the shape of their corallites results in their being placed in different genera, as now defined. The specimen under consideration resembles and may be conspecific with *H. agglomeratiformis* Whitfield, which was originally described from the Ordovician of east-central Ellesmere Island and has since been described from the lower part of the Ordovician Cape Calhoun beds of northwestern Greenland.

The fourth specimen in the collection we are studying does not merit detailed description or illustration. It seems to resemble the one just described, with which it was found in association.

Occurrence.—The specimen represented by figure 9 on plate 7 was secured by Mr. and Mrs. F. Ray Ross on Sutton Island, presumably from float. Our largest specimen (pl. 2, figs. 1, 2) is from an erratic boulder of light-colored dolomite about 2 miles east-northeast of the Hudson's Bay Company Holman Island Post on the surface of a 500 to 600-foot trap plateau on the north shcre of Prince Albert Sound, Victoria Island. The other two specimens, one of which is represented by figure 3 on plate 1, are from light-colored dolomite float on Read Island.

Repositories.—University of Alberta, 544 (pl. 7, fig. 9); and Yale Peabody Museum, 17297 (includes pl. 1, fig. 3), 17303 (pl. 2, figs. 1, 2).

ARCTURIA sp.
Plate 1, figure 2

From dolomite float on Read Island, Preston Cloud collected two specimens that seem to resemble the forms for which Wilson (1931, pp. 294–296) proposed the name *Arcturia*. She states that

> *Arcturia* resembles *Halysites* in having corallites which are connected by the edges. The corallite, however, is polygonal, not oval as in *Halysites*, nor rounded as in *Syringopora*.

In both of our specimens the corallites are small and are polygonal in cross section. In the larger of these two specimens there are several rounded clusters of corallites reminiscent of that which occurs in the representative of *Halysites* illustrated by figure 3 on our plate 1. Two of these clusters in our *Arcturia* are shown by figure 2 on the same plate.

EXPLANATION OF PLATE 3

FIGS. *1, 2—Liospira progne* (Billings). A large but otherwise typical internal mold from Fossil Point on Read Island, ×1. See also figs. *8, 9*. (p. 8)

3–5—Lophospira Miller and Youngquist, n. sp. *3*, An artificial cast of a specimen from Sutton Island, ×2. *4*, An internal mold from Fossil Point on Read Island, ×1½. *5*, A fairly complete specimen from southwestern Victoria Island, ×1½ (p. 8)

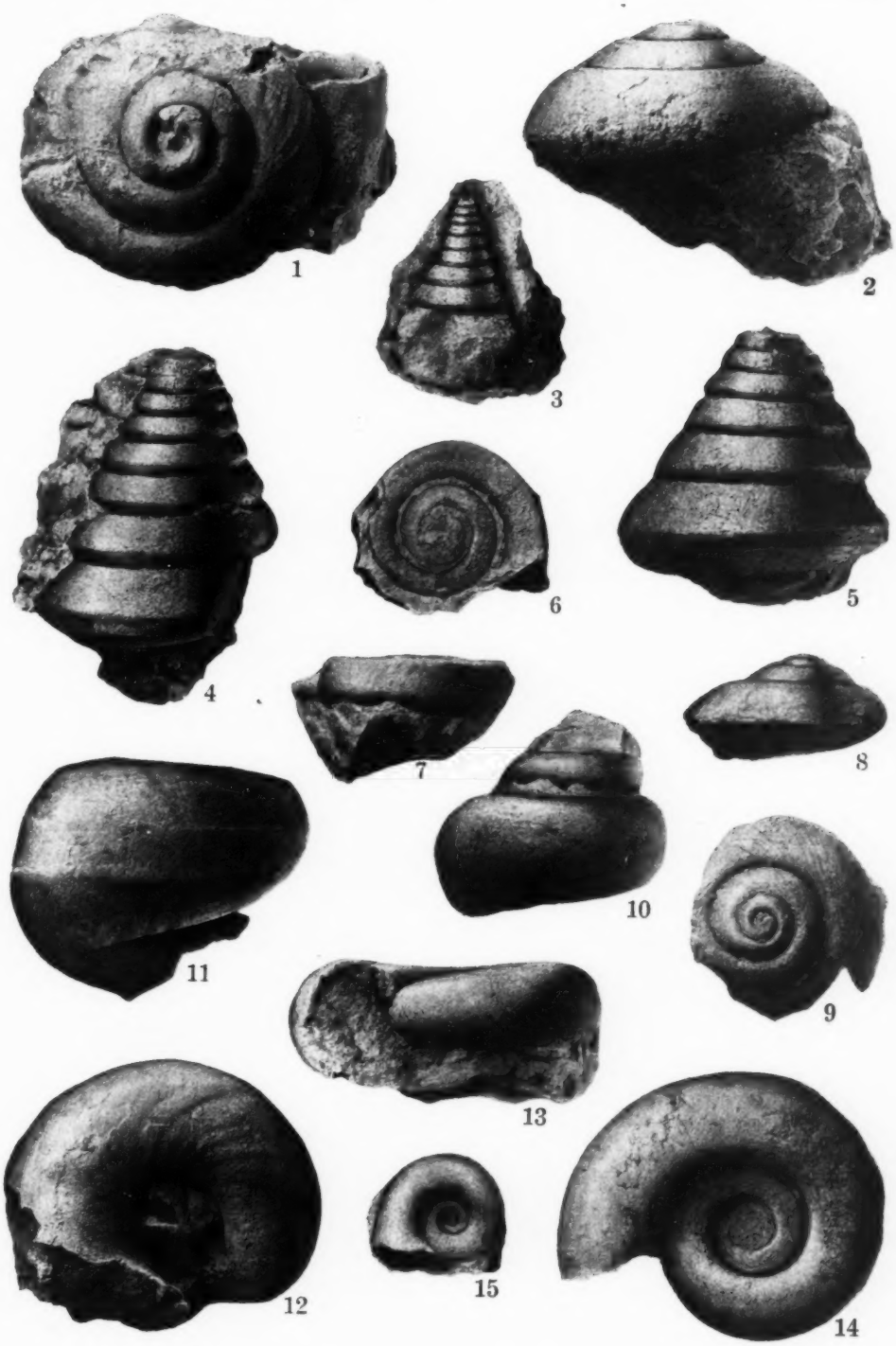
6, 7—Ophileta aff. *O. compacta* Salter. Two views of a small specimen from Fossil Point on Read Island, ×1½. (p. 7)

8, 9—Liospira progne (Billings). A small internal mold from Fossil Point on Read Island, ×1½. See also figs. *1, 2*. (p. 8)

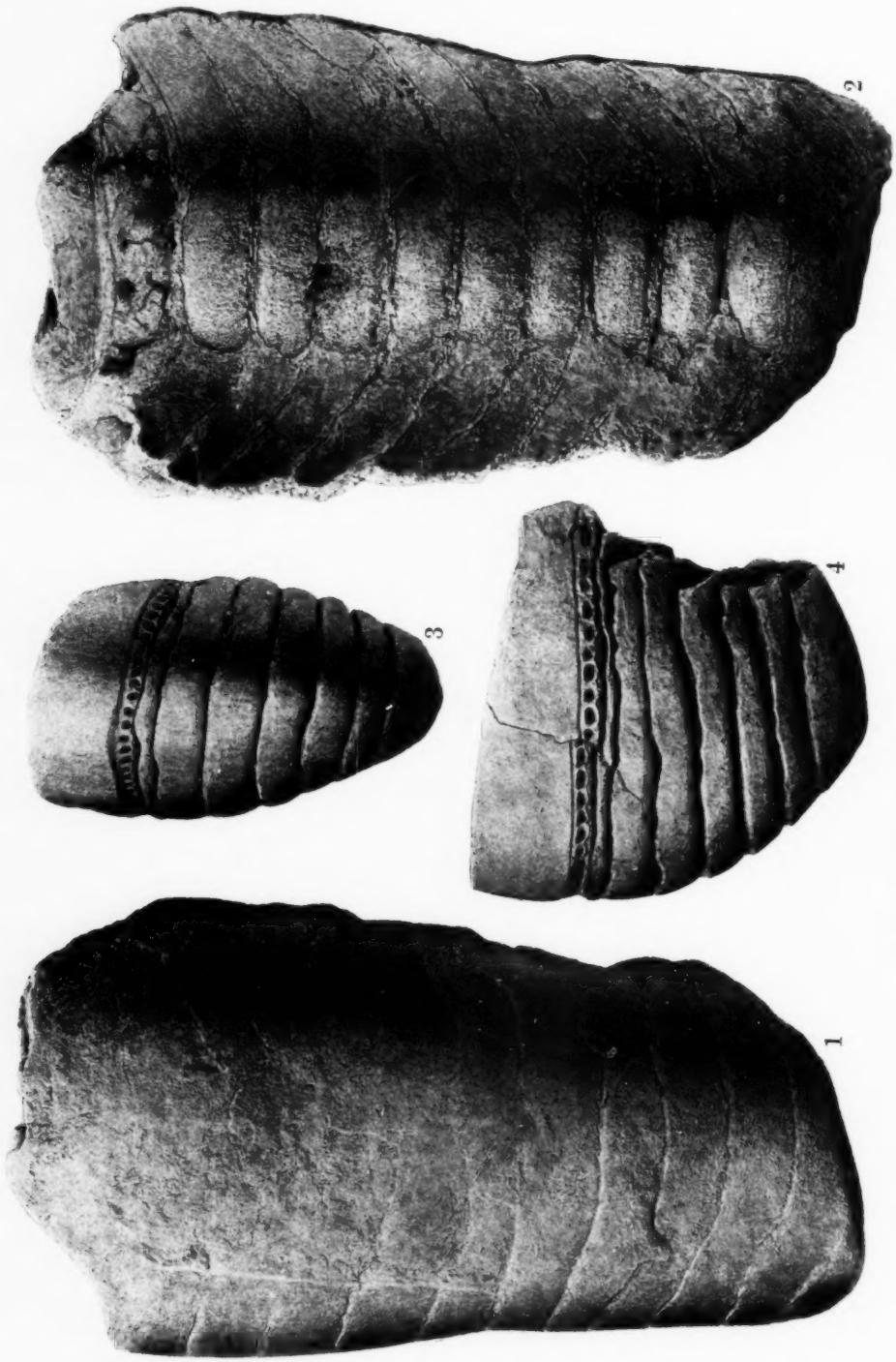
10—Sellinema? sp. A specimen from Fossil Point on Read Island, ×1½. (p. 10)

11, 12—Holopea sp. Two views of a single specimen from the same horizon and locality as the preceding. ×1½. (p. 10)

13–15—Bucania elliptica Ulrich and Scofield. Two specimens from Fossil Point on Read Island ×1½. (p. 7)



Miller and Youngquist, Ordovician Fossils



Miller and Youngquist, Ordovician Fossils

Occurrence.—Our two specimens are from light-colored dolomite float on Read Island. Those studied by Wilson came from "Silurian or Ordovician" drift on Fossil Island in Lake Nettilling, Baffin Island. Wilson also refers to *Arcturia* specimens described by Troedsson from the Upper Ordovician Cape Calhoun beds of northwestern Greenland.

Repository.—Yale Peabody Museum, 17299.

STREPTELASMA? spp.

The collections under consideration contain 18 small fragmentary horn corals. All of these are less than 30 mm. in diameter, and the length of the best individual, which is complete adapically, is some 25 mm. The preservation of the specimens leaves much to be desired. However, all of the characters that can be discerned seem to coincide with those of *Streptelasma*, and accordingly we are tentatively referring them to that genus.

Occurrence.—Fourteen specimens are from cream-colored dolomite of an east-central promontory on Sutton Island. One specimen is from dolomite float on Read Island. The other three specimens were found in erratic boulders of gray dolomite about 2 miles east-northeast of the Hudson's Bay Company Holman Island Post on the surface of a 500 to 600-foot trap plateau on the north shore of Prince Albert Sound, Victoria Island.

Repository.—Yale Peabody Museum, 17301 (1 specimen), 17305 (3 specimens), 17341 (7 specimens), 17342 (1 specimen), 17344 (1 specimen), 17346 (2 specimens), 17349 (2 specimens), 17359 (1 specimen).

BUCANIA ELLIPTICA Ulrich and Scofield
Plate 3, figures 13–15

Bucania elliptica ULRICH and SCOFIELD, 1897, Minnesota Geol. and Nat. History Survey, vol. 3, pt. 2, p. 888, pl. 66, figs. 11, 12.

More than 60 specimens from Read and Sutton islands are referred to this species. All of them are internal molds. The largest and best preserved is represented by figures 13 and 14 on plate 3. It is not complete adorally, but the preserved portion of it is about 31 mm. in diameter. The great majority of our specimens are in the vicinity of 20 mm. in diameter.

The adapical portion of the large figured specimen is not well preserved. However, a comparison with the specimen represented by figure 15 on the same plate makes it clear that at full maturity the conch of this species consist of at least three volutions. The whorls are approximately as high as wide, and they increase in diameter very gradually. The coiling is planispiral, or essentially so.

Remarks.—Our specimens seem to resemble closely the figured syntype of this species, in which, however, the whorls are slightly wider than high. That specimen, like all of ours, is an internal mold.

This form approximates the type species of *Bucania* Hall more closely than any other genotype with which we are familiar. Therefore, we are following Ulrich and Scofield and leaving it in that genus.

Occurrence.—All of our specimens are preserved in white dolomite, and all are lithologically very similar. Some 40 of them (including both of those figured) are from Fossil Point on Read Island. Approximately 20 are from ±45 ft. above tide at the northwest end of Sutton Island. The syntypes of this species came from the Prosser limestone south of Cannon Falls, Minnesota, and the "base of Trenton or top of Black River group" in Mercer County, Kentucky.

Repository.—Yale Peabody Museum, 17261A, 17276–17282—both of the figured specimens are included in 17276.

OPHILETA aff. O. COMPACTA Salter
Plate 3, figures 6, 7

The figured specimen resembles *Ophileta compacta* Salter but appears to be specifically distinct from it. The maximum diameter of the preserved portion of this internal

EXPLANATION OF PLATE 4

FIGS. *1, 2*—*Armenoceras* sp. Two views of a specimen from Sutton Island, ×1. See also figs. *1–3, 5, 6*, pl. 5; fig. *8*, pl. 6; figs. *1, 2*, pl. 7; figs. *4–6*, pl. 8; and figs. *1–6*, pl. 9. (p. 16)

3, 4—*Suttonoceras rossorum* Miller and Youngquist, n. sp. The holotype from Sutton Island, ×1. (p. 13)

mold is about 17 mm. The spire is essentially flat and it shows that the conch consisted of at least three volutions. The peripheral zone is almost flat and is approximately normal to the spire surface. The upper peripheral shoulder is angular and immediately below it on the flattened peripheral zone there is a slight but distinct longitudinal groove. The lower peripheral shoulder is rounded. On the flattened peripheral zone there are traces of growth increments which slope obliquely apicad from the lower to the upper peripheral shoulder.

Remarks.—*Ophileta compacta* Salter of the Lower Ordovician of the Montreal region, though in general similar to our form, does not have a flattened peripheral zone normal to the spire surface. Also, in that species there is no longitudinal groove below the upper peripheral shoulder.

Occurrence.—White dolomite on Fossil Point, Read Island.

Repository.—Yale Peabody Museum, 17283.

LOPHOSPIRA, n. sp.
Plate 3, figures 3–5

Three localities in the area under consideration have yielded specimens that seem to be referable to *Lophospira* but are specifically distinct from all previously described representatives of that genus. Inasmuch as none of these specimens retains the shell or the surface markings thereof, we are not proposing a name for the species or designating a holotype.

The over-all length of the individual represented by figure 4 on plate 3 is about 29 mm., and that of figure 5 on the same plate is about 25 mm. The maximum diameter attained by the latter is about 26 mm.—some fragmentary specimens appear to have had slightly larger dimensions. Figure 3 on this plate represents an artificial cast that we are tentatively including in this species.

Occurrence.—White dolomite at Fossil Point on Read Island (22 specimens, including fig. 4, pl. 3), 55 ft. above tide on the southwest side of Sutton Island (12 specimens, including fig. 3, pl. 3), and 30–35 ft. above tide half a mile inland on Victoria Island just north of Read Island (1 specimen—fig. 5, pl. 3).

Repository.—Yale Peabody Museum, 17285, 17289 (includes fig. 4, pl. 3), 17290 (includes fig. 3, pl. 3), 17292–17295, 17296 (fig. 5, pl. 3).

LIOSPIRA PROGNE (Billings)
Plate 3, figures 1, 2, 8, 9

Pleurotomaria progne BILLINGS, 1860, Canadian Naturalist and Geologist, vol. 5, pp. 163–164, fig. 6.

Pleurotomaria progne Billings. BILLINGS, *in* LOGAN *et al.*, 1863, Canada Geol. Survey Rept. Progress to 1863, pp. 181, 948, fig. 176.

Pleurotomaria progne Billings. LESLEY, 1889, Pennsylvania Geol. Survey Rept. P. 4, vol. 2, p. 714.

Liospira progne (Billings). ULRICH and SCOFIELD, 1897, Minnesota Geol. and Nat. History Survey, vol. 3, pt. 2, pp. 996–997, pl. 68, figs. 38–44.

Liospira progne (Billings). GRABAU and SHIMER, 1909, North American index fossils, Invertebrates, vol. 1, p. 640, figs. 871e–g.

Liospira progne (Billings). TROEDSSON, 1928, Medd. om Grønland, Bd. 72, p. 16, pl. 2, figs. 7, 8; pl. 25, fig. 5.

Liospira progne (Billings). KNIGHT, BRIDGE, SHIMER, and SHROCK *in* SHIMER and SHROCK, Index fossils of North America, p. 453, pl. 183, figs. 13–15.

Read, Sutton, and Victoria islands have yielded some 60 specimens that are referable to the genus *Liospira*, as now understood. All of these are internal molds preserved in dolomite. Many of them are fragmental and are somewhat distorted.

As might be expected, a considerable amount of variation in size and details of shape are apparent in this group of specimens. The individual represented by figures 1 and 2 on plate 3 is fairly typical but is slightly larger than average—however, one exceptionally large specimen (from Victoria Island) attains a diameter of some 60 mm. Traces of the growth lines are clearly discernible on many of the specimens. As shown by figures 8 and 9 on the same plate, the periphery in the earlier volutions is acutely angular, whereas at full maturity it is relatively obtuse. Broken specimens elucidate this ontogenetic change in the periphery.

Remarks.—The syntypes of this species came from several horizons and localities, and the published illustration and description leave much to be desired. Specimens

that have in the past been referred to this species reveal a considerable amount of variation and suggest that the species has been interpreted rather broadly. Our specimens likewise are somewhat variable insofar as size, height of spire, and whorl cross section are concerned. At least some of them could be referred with about equal propriety to *L. obtusa* Ulrich and Scofield. However, the differences exhibited are gradational, and presumably all of our specimens are conspecific.

Occurrence.—Fossil Point on Read Island (26 specimens, including both of those figured); ±45 ft. above tide, northwest end of Sutton Island (10 specimens); ±30 ft. above tide, east end of southeast promontory of Sutton Island (2 specimens); ±55 ft. above tide, southwest side of Sutton Island (20 specimens); and 30 to 35 ft. above tide, Victoria Island, just north of Read Island, about half a mile inland (2 specimens).

The syntypes of this species are stated to be from the Trenton limestone of "Ottawa; near Montreal; Belleville; Trenton, and numerous other localities" in Canada. Ulrich and Scofield indicate that conspecific specimens occur in the

> Stones River group, Murfreesboro and Lebanon, Tennessee; Black River and Trenton groups, Mercer county, Kentucky, . . . ; [and] Trenton, group, Clitambonites and Fusispira beds, Goodhue and Fillmore counties, Minnesota.

Also, according to Troedsson, this species is represented in the Cape Calhoun beds of northern Greenland.

Repository.—Yale Peabody Museum, 17251–17266, 17269–17271, 17274A, 17288, 17291, 17325—the figured specimens are 17254 (figs. 1, 2) and 17271 (figs. 8, 9).

ECCYLIOPTERUS? sp.

Preston Cloud collected two specimens on Victoria Island that are superficially similar to our *Ophileta* aff. *O. compacta* Salter but have narrower, more numerous whorls and a depressed spire. Both are poorly preserved internal molds. The larger specimen consists of at least five whorls, and the preserved part of it is about 22 mm. in diameter. The smaller specimen is only about 14 mm. in diameter.

In general these specimens resemble *Eccyliopterus ottawaensis* (Billings) of the "Trenton" near Ottawa, Ontario. However, their poor preservation precludes detailed comparisons. Neither of our specimens merits illustration, and we are mentioning them for the sake of completeness and to call attention to the possible occurrence of this genus in the area under consideration.

Occurrence.—Erratic boulders of white dolomite on the shore near the Hudson's Bay Company Holman Island Post on the northwest side of Prince Albert Sound, Victoria Island.

Repository.—Yale Peabody Museum, 17284.

MACLURINA cf. M. MANITOBENSIS (Whiteaves)

Plate 6, figures 3–5

Three specimens from Sutton Island are herewith compared with *M. manitobensis* of the Red River, Bighorn, and equivalent formations. The largest of these (not illustrated) is only about 70 mm. in diameter; the next (pl. 6, figs. 3–5) is about 64 mm. in diameter; the third (not illustrated) is considerably crushed and distorted but is distinctly smaller than the other two.

The surface markings of the conch are not preserved on any of these specimens. In general physiognomy and in all preserved particulars they seem to agree well with typical representatives of *M. manitobensis*, which, however, are known to attain a much larger size.

In his well-known study of Paleozoic gastropod genotypes, Knight (1941, pp. 183–186) indicates that *Maclurina* Ulrich and Scofield and *Maclurites* Le Sueur are generically distinct. However, in collaboration with Bridge, Shimer, and Shrock, he (1944, pp. 467–468) seems to suggest that the two should be regarded as synonyms, though in view of the fact that the latter reference apparently contains a typographical error, its meaning is not entirely clear.

The species with which we are comparing our specimens is the genotype of *Maclurina*, and therefore we are using that name.

Occurrence.—The largest of our specimens is from gray dolomite float on Sutton Island; the other two are from dark-gray dolomite 0–15 ft. above tide on the south side of an east-central promontory on the same island.

Repository.—Yale Peabody Museum, 17333 (largest specimen), 17334 (2 other specimens).

SELLINEMA? sp.
Plate 3, figure 10

From one locality, Fossil Point on Read Island, we have four moderately small internal molds that in general physiognomy seem to resemble the genotype of *Sellinema, S. dive* Perner from the Silurian of Bohemia. Also, faint traces of growth lines that can be discerned on the largest of our specimens form a rounded sinus on the outer side of the whorls, much as in that genotype. The whorl profile is uniformly rounded, the sutures are deep, and the umbilicus is fairly large. The over-all height of the largest of our specimens (the one figured) is about 22 mm., and the maximum diameter measures about the same.

Superficially this form seems to resemble one from Iglulik Island that Teichert (1937, pl. 13, figs. 5, 6) illustrated as *Trochonema* cf. *T. umbilicatum* (Hall). Also it resembles *Holopea excelsa* Ulrich and Scofield. All of these forms are very similar in outline and are distinguished by characters not preserved on our specimen.

Occurrence.—Fossil Point on Read Island.

Repository.—Yale Peabody Museum. 17273.

HOLOPEA sp.
Plate 3, figures 11, 12

The individual figured is typical of a group of seven specimens in the collections we are studying. It is about 31 mm. in diameter, but another individual from the same locality attains a diameter of about 47 mm. In all of the specimens under consideration, the conch is very low spired and is rapidly expanded orad. The whorls are rounded in profile, and the growth lines on them form a deep sinus on the outer side of the volution. The umbilicus is moderate in size.

Occurrence.—White dolomite at Fossil Point on Read Island (6 specimens, including the one figured), and ±45 ft. above tide at northwest end of Sutton Island (1 specimen).

Repository.—Yale Peabody Museum, 17267, 17268 (Sutton Island specimen), 17272, 17273A (figured specimen), 17274, 17275, 17286.

GENUS BOREOCERAS Miller and Youngquist, n. gen.

Genotype, *Boreoceras washburni*, n. sp.

Conch breviconic, slightly curved, and in cross section subcircular or laterally compressed. Camerae short. Sutures directly transverse, or essentially so, and they form slight lateral lobes and corresponding dorsal and ventral saddles. Siphuncle rather large, composed of nearly cylindrical segments, and dorsal but not quite marginal in position—the concave side of the conch is believed to be dorsal. Known from only the Ordovician of Read and Sutton islands.

The four species that we are placing in this genus differ particularly from one another in the shape of the cross section of the conch. It varies from circular, or nearly so, to rather narrowly elliptical. Presumably all four of these species occur in rather close association, and in the future intermediate forms are likely to be found.

Cyrtendoceras Remelé, which is known from only the Chazyan equivalent in the Baltic region, is close to our genus, but its conch is transversely annulated. *Oelandoceras* Foerste, of the same general horizon and locality, has a somewhat similar conch, but its siphuncle is small. Foerste (1932, p. 164) states that

> both *Cyrtendoceras* and *Oelandoceras* have their siphuncles located on the concave side of the conch, and therefore are endogastric.

It seems to us more likely that they, and likewise *Boreoceras*, are exogastric, for as Hyatt (1900, p. 510) has pointed out,

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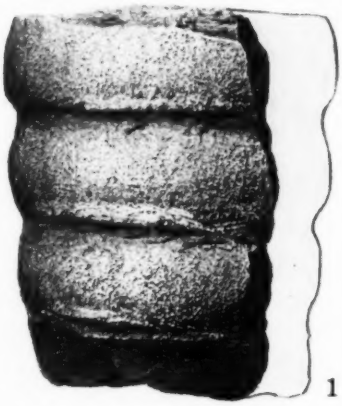
EXPLANATION OF PLATE 5

FIGS. *1–3*—*Armenoceras* sp. Three views of a siphuncle from Sutton Island, ×1. See also figs. *5, 6*. (p. 16)

4—*Discoceras?* sp. A specimen from Sutton Island, ×1. (p. 15)

5, 6—*Armenoceras* sp. Two views of a specimen from Sutton Island, ×1. See also figs. *1–3*; figs. *1, 2*, pl. 4; fig. *8*, pl. 6; figs. *1, 2*, pl. 7; figs. *4–6*, pl. 8; and figs. *1–6*, pl. 9. (p. 16)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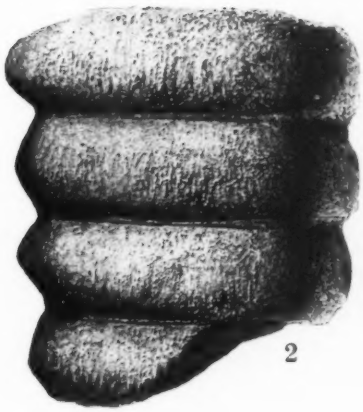
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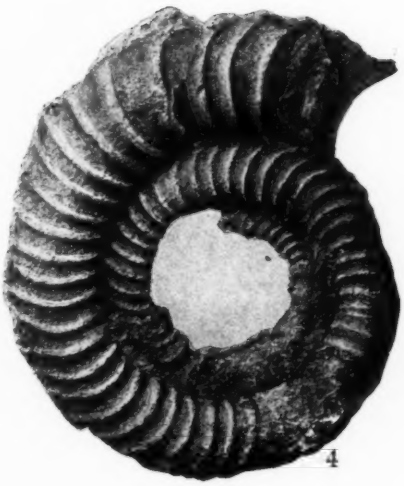
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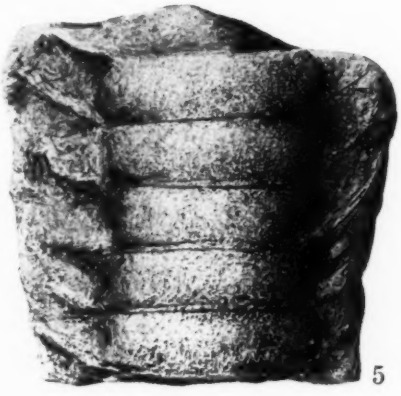
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6

Miller and Youngquist, Ordovician Fossils

Miller and Youngquist, Ordovician Fossils

most curved forms have the ventral sinus on the arched external side (*exogastric* shells), but some have it on the concave internal side, as in *Phragmoceras*, and these are called *endogastric* shells.

It is probable that, as was his custom, Foerste assumed that the concave side of the conch in *Cyrtendoceras* and *Oelandoceras* is ventral merely because the siphuncle is located close to it. Growth lines are preserved in one of the representatives studied by him, but they are straight and directly transverse and therefore give no indication of a hyponomic sinus, which is invariably ventral in position and accordingly serves to orient the conch.

BOREOCERAS WASHBURNI Miller and Youngquist, n. sp.
Plate 7, figures 6–8

Conch moderate in size, rather rapidly expanded orad, slightly but distinctly curved longitudinally, and broadly elliptical in cross section being laterally compressed. The specimen represented by figures 6 and 7 on plate 7 has an over-all length of about 80 mm., and its maximum height of conch measures about 40 mm.—approximately three-eighths of its length represents living chamber. At the junction of the phragmacone and the living chamber of this specimen, the conch is about 33 mm. high and its width is estimated to be some 22 mm. The other syntypes, including the one represented by figure 8 on the same plate, are so fragmentary that precise measurements have little significance, but it should be mentioned that two of them are slightly larger than the best specimen (pl. 7, figs. 6, 7).

No trace of surface ornamentation can be discerned on any of the five syntypes, all of which are internal molds. The camerae are short, and their length averages approximately one-fifteenth their height. The sutures are slightly sinuous, forming broad, shallow, rounded lateral lobes and low dorsal and ventral saddles. In one of the unfigured syntypes, the sutures form rather small but prominent ventrolateral lobes on the side of the conch that is preserved—presumably these are due to distortion during preservation.

The siphuncle is rather large, is dorsal but not quite marginal in position, and is composed of nearly cylindrical segments. That of the specimen represented by figure 8 on plate 7 attains a maximum diameter of about 11 mm., and its surface bears fine closely spaced markings that are oblique, sloping rather strongly orad toward the dorsum.

Remarks.—The conch of this species is elliptical in cross section, rather than circular as is that of *B. cloudi*. Its ellipticity is due to lateral compression, but the conch is not as strongly compressed as are those of the other two known congeneric forms, *B. brevicameratum* and *B. parvulum*.

Occurrence.—Light-colored dolomite about 55 feet above sea level on the southwest side of Sutton Island (2 specimens including figs. 6, 7 on pl. 7); about 45 feet above tide on the northwest end of the same island (1 unfigured specimen); and Fossil Point of Read Island (2 specimens including fig. 8 on pl. 7).

Repository.—Yale Peabody Museum, 17312A (pl. 7, figs. 6, 7), 17312B, 17316, 18317A (pl. 7, fig. 8), 17321.

BOREOCERAS BREVICAMERATUM Miller and Youngquist, n. sp.
Plate 6, figures 1, 2

The most abundant of the four known species of *Boreoceras* is characterized particularly by the shortness of its camerae. At least the adoral portion of its conch is only slightly curved longitudinally and is strongly compressed laterally. The cross section is

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EXPLANATION OF PLATE 6

FIGS. *1, 2*—*Boreoceras brevicameratum* Miller and Youngquist, n. sp. Two views of the holotype from Read Island, ×1. (p. 11)

3–5—*Maclurina* cf. *M. manitobensis* (Whiteaves). An internal mold, and two views of the inner whorls of the same specimen, from Sutton Island, ×1. (p. 9)

6, 7—*Boreoceras cloudi* Miller and Youngquist, n. sp. The holotype from Sutton Island, ×1. (p. 12)

8—*Armenoceras?* sp. A specimen from Sutton Island, ×1. See also figs. *1, 2*, pl. 4; figs. *1–3, 5, 6*, pl. 5; figs. *1, 2*, pl. 7; figs. *4–6*, pl. 8; and figs. *1–6*, pl. 9. (p. 16)

elliptical, as the conch is very broadly rounded laterally and is narrowly rounded both dorsally and ventrally. The figured specimen, the holotype, is about 40 mm. long, and approximately a third of its length represents phragmacone. At the junction of the phragmacone and the living chamber of this specimen, the conch is about 35 mm. high and 20 mm. wide. Some of the paratypes are distinctly larger than the holotype, but their fragmentary nature makes it impossible to obtain significant measurements.

At least the internal mold is smooth and is devoid of ornamentation. The camerae are very short even in the mature portions of the conch, and those of the holotype average only about 1½ mm. in length. The sutures are rather strongly sinuous, forming broad rounded lateral lobes and narrowly rounded dorsal and ventral saddles. The siphuncle of the holotype is not well preserved, but that of one of the paratypes (which is of about the same size as the holotype) is located very close to the dorsal wall of the conch and is about 9 mm. in diameter where the conch is about 39 mm. high and 27 mm. wide.

Remarks.—In general physiognomy, the conch of this species resembles that of *B. parvulum*. However, the syntypes of that species, which are all of about the same size, are very much smaller.

Occurrence.—Light-colored dolomite on Fossil Point of Read Island (holotype and 9 paratypes) and about 55 feet above sea level on the southwest side of Sutton Island (4 paratypes).

Repository.—Yale Peabody Museum, 17310, 17311B, 17312 (Sutton Island specimens), 17313 (holotype), 17314, 17324.

BOREOCERAS CLOUDI Miller and Youngquist, n. sp.
Plate 6, figures 6, 7

The holotype of this species is an internal mold of most of the living chamber and much of the phragmacone. It is cyrtoceraconic, but is only slightly curved; and it is breviconic, but, for a brevicone, is not very rapidly expanded orad. The cross section of the conch is circular or nearly so, and its diameter measures about 22 mm. at the adapical end of the holotype, about 28 mm. near the junction of the phragmacone and the living chamber, and about 34 mm. near the adoral end of the specimen.

The living chamber bears two slight constrictions, one near its midlength and the other on its adoral half. Both of these are only a millimeter or two wide and a fraction of a millimeter deep. They are oblique to the long axis of the conch, sloping orad from the venter. Presumably these constrictions represent internal thickenings of the test, but they may, of course, have been constrictions of the conch.

The camerae are numerous and are very short. The portion of the phragmacone of the holotype that is preserved is about 24 mm. long, but it represents 13 camerae. The sutures are almost directly transverse, but they are slightly sinuous, forming very shallow lateral lobes and corresponding dorsal and ventral saddles.

The siphuncle is large and is located close to the dorsal (concave) side of the conch, but apparently is not in contact with it. At the junction of the phragmacone and the living chamber of the holotype, the siphuncle is some 8 mm. in diameter, and it is estimated to be about 2 or 3 mm. from the dorsum—the extreme dorsal portion of the specimen is unfortunately not preserved.

Remarks.—We refer a poorly preserved fragment to this species with question. All of its characters that can be discerned seem to coincide well with those of the holotype, but it appears to be some 25 per cent larger.

In general, *B. cloudi* resembles the three other species that we regard as congeneric. However, it differs from them in that its conch is not laterally compressed but is circular, or nearly so, in cross section.

Occurrence.—Light-colored dolomite about 55 feet above sea level on the southwest side of Sutton Island. The large specimen that we are referring to this species with question is from Fossil Point on Read Island.

Repository.—Yale Peabody Museum, 17312 (holotype), 17311A (questionable representative of species).

BOREOCERAS PARVULUM Miller and Youngquist, n. sp.
Plate 7, figures 3–5

Four small specimens from Read Island represent a distinct species that appears to

be referable to *Boreoceras*. None of these is complete, but they supplement one another fairly well. All of them are of about the same size.

The conch is rather rapidly expanded orad, is breviconic, and is very slightly curved longitudinally. It is strongly compressed laterally and is narrowly rounded both dorsally and ventrally. One of the unfigured syntypes shows that the living chamber attains a maximum length of at least 22 mm.

No trace of surface ornamentation can be discerned on any of the four syntypes. In all of them the camerae are very short. The sutures form broad rounded lateral lobes and narrowly rounded dorsal and ventral saddles. In the specimen represented by figures 4 and 5 on plate 7, there is a structure that may represent the siphuncle, but it is located in the poorly preserved dorsal portion of the conch.

Remarks.—This species resembles rather closely *B. brevicameratum*, with which it occurs in close association. However, in that form the conch apparently attained a much larger size.

Occurrence.—Light-colored dolomite on Fossil Point, Read Island.

Syntypes.—Yale Peabody Museum,17317B (pl. 7, fig. 3), 17317C, 17320 (pl. 7, figs. 4, 5), 17328.

Genus SUTTONOCERAS Miller and Youngquist, n. gen.

Genotype, *Suttonoceras rossorum*, n. sp.

Conch breviconic, cyrtoceraconic, and laterally compressed. At maturity living chamber is contracted adorally. Sutures essentially straight and directly transverse. Siphuncle dorsal but not marginal in position; apparently its segments are considerably expanded within the camerae, and it is actinosiphonate. Known from only the Ordovician of Sutton Island, after which the genus is named.

Suttonoceras is perhaps closer to *Codoceras* Hyatt than to any other actinosiphonate genus with which we are familiar. In the type species of that genus, *Cyrtoceras indomitum* Barrande of the Middle Silurian of Bohemia, the conch is not as strongly curved as in our form, the siphuncle is subcentral in position, and the living chamber is not contracted adorally. The growth lines in this Silurian species show that the hyponomic sinus is on the concave side of the conch and that the curvature is therefore endogastric. The orientation of the only known representative of *Suttonoceras* is uncertain, but tentatively we regard the concave side as dorsal. *Codoceras schmidti* Teichert of the Upper Ordovician Lyckholm beds of the Baltic region may possibly belong in *Suttonoceras*, but such of its characters as are known seem to coincide well with those of *Codoceras*.

The great majority of the forms in which actinosiphonate structure has been observed are Silurian and Devonian in age. However, Foerste (1926, pp. 288–289, 323–327) has recorded siphuncles of this type from the Upper Ordovician of Ohio, Kentucky, Tennessee, and Anticosti Island, and Miller (1932, pp. 272–273) has described what may well be traces of actinosiphonate structure from the Bighorn formation of Wyoming. Also, published illustrations of certain older forms suggest that they may be actinosiphonate, for example, *Actinoceras turinense* Foerste and *A. janesvillense* Foerste, both of the Middle Ordovician Platteville formation of the Upper Mississippi Valley.

SUTTONOCERAS ROSSORUM Miller and Youngquist, n. sp.
Plate 4, figures 3, 4

The only known representative of this species is an internal mold representing much of a phragmacone and the adjacent portion of the living chamber. The conch is short, is rather strongly curved, and is oval in cross section—it is compressed laterally and its dorsal (siphuncular) side is somewhat more narrowly rounded than its ventral (convex) side. The over-all length of this specimen measures about 58 mm., and at the junction of the phragmacone and the living chamber the conch is about 57 mm. high and 35 mm. wide. The living chamber is distinctly contracted orad, and the maximum transverse dimensions of the shell seem to have been attained at or near the adoral end of the phragmacone. The adapical portion of the phragmacone is rapidly expanded orad. The ventral side of the conch is rather strongly convex. The dorsal side of the phragmacone is unfortunately

not preserved in the holotype. However, the dorsal portion of the adapical part of the living chamber is represented, and this makes it clear that that segment of the conch was contracted orad.

The sutures are essentially straight and directly transverse, though the holotype has been slightly distorted during preservation. The adoral camera of this specimen appears to be slightly shorter than the preceding one, indicating that we are dealing with a fully mature individual. The length of the other six camerae of the holotype is fairly constant and, measured along the lateral zones of the conch, averages approximately 6 mm. At the junction of the phragmacone and the living chamber, there is a transverse line parallel to the sutures, and also there is a row of small shallow rounded or elliptical depressions. Presumably these structures represent a zone of attachment of the animal to the conch.

The siphuncle is dorsal but not marginal in position. In the adoral portion of the holotype, at its passage through the penultimate septum, the siphuncle is about 6 mm. wide and its height is about twice that amount. At this places the siphuncle is some 4 mm. from the dorsum. The siphuncular segments appear to be considerably expanded within the camerae but hardly enough to be nummuloidal. In the adoral portion of the phragmacone of the holotype, there is preserved an internal and an external mold of part of the siphuncle. These indicate that the siphuncle was actinosiphonate; that is, that on the inside of it there were some 25 longitudinal lamellae which converged toward but did not reach the center.

Remarks.—The specific name is given in honor of Mr. and Mrs. F. Ray Ross who collected the holotype—Mr. Ross was the Hudson's Bay Company factor at Holman Post, Northwest Territories. Inasmuch as this species is the only known representative of the genus, there is no form with which it can be specifically compared to advantage.

Occurrence.—Light-gray dolomite on Sutton Island.

Holotype.—University of Alberta, 546.

GORBYOCERAS cf. G. GERONTICUM (Foerste and Savage)

Plate 8, figures 1–3

?Spyroceras geronticum FOERSTE and SAVAGE. 1927, Denison Univ. Bull., Jour. Sci. Labs., vol. 22, pp. 38–39, pl. 5, figs. 2, 3; pl. 6, figs, 1A, 1B.

?Gorbyoceras geronticum (Foerste and Savage). FLOWER, 1946, Bull. Am. Paleontology, vol. 29, no. 116, p. 148.

We have two specimens from Sutton Island that belong in the genus *Gorbyoceras*. All but possibly the extreme adoral part of the smaller of these (pl. 8, figs. 1, 2) represents phragmacone, whereas the other specimen appears to be largely, if not entirely, nonseptate and therefore to represent living chamber. Both are laterally compressed and are broadly elliptical in cross section. The smaller specimen is about 85 mm. long, and its two diameters measure about 12 mm. and 16 mm. near its adapical end and about 17 mm. and 25 mm., respectively, near its adoral end. The larger specimen is about 115 mm. long, and near its midlength its two diameters measure about 20 mm. and 30 mm. Figure 3 on our plate 8 suggests that the anterior portion of the larger specimen is contracted adorally, but that part of the specimen is incomplete laterally.

Both specimens are distinctly curved longitudinally, which, of course, may be original, or may be due to distortion during preservation. The conch bears prominent transverse annulations, and in both of our specimens the distance between successive

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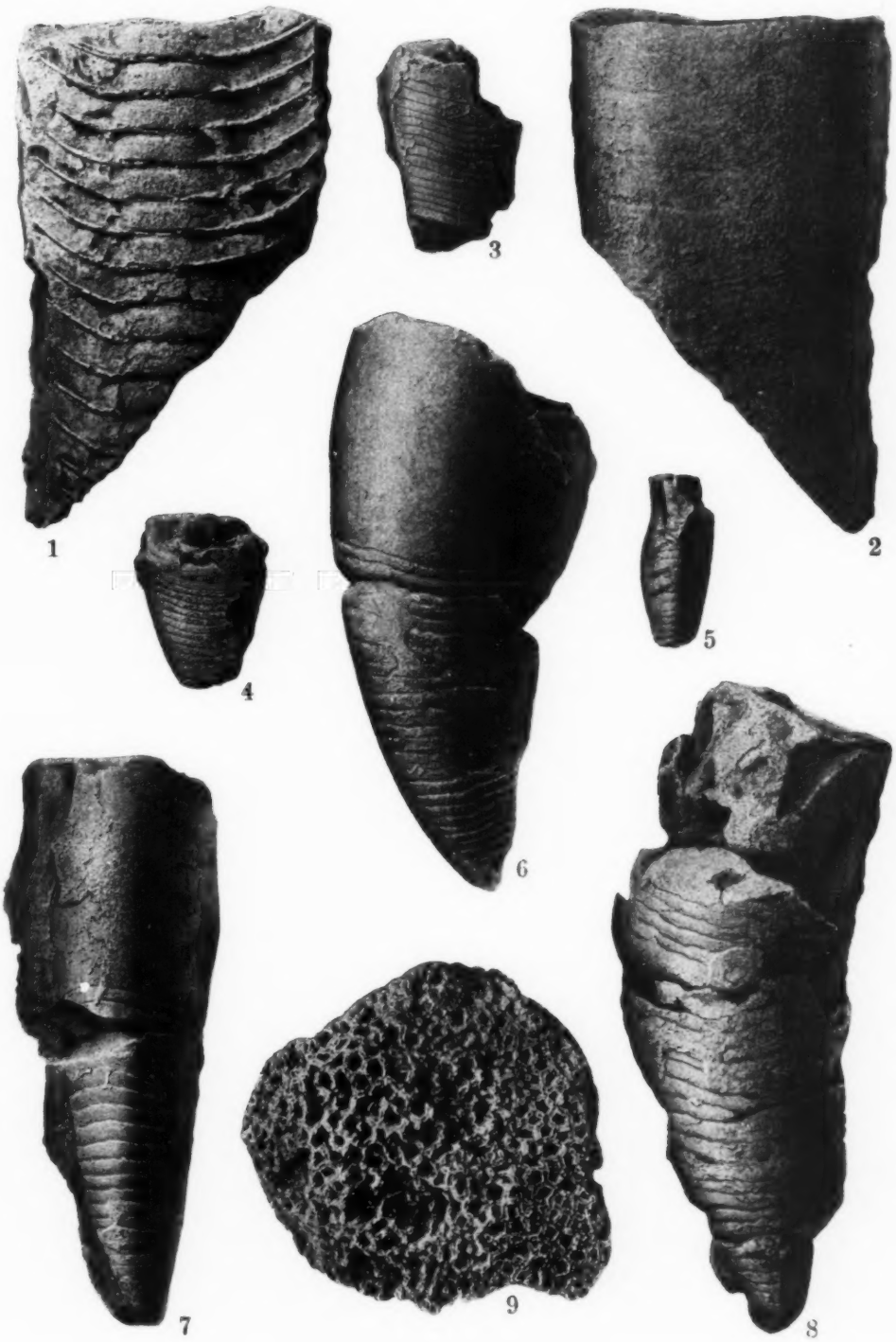
EXPLANATION OF PLATE 7

FIGS. *1, 2*—*Armenoceras* sp. Two views of a specimen from a small island about 1 mile northwest of Read Island, ×1. See also figs. *1, 2*, pl. 4; figs. *1–3, 5, 6*, pl. 5; fig. *8*, pl. 6; figs. *4–6*, pl.8; and figs. *1–6*, pl. 9. (p. 14)

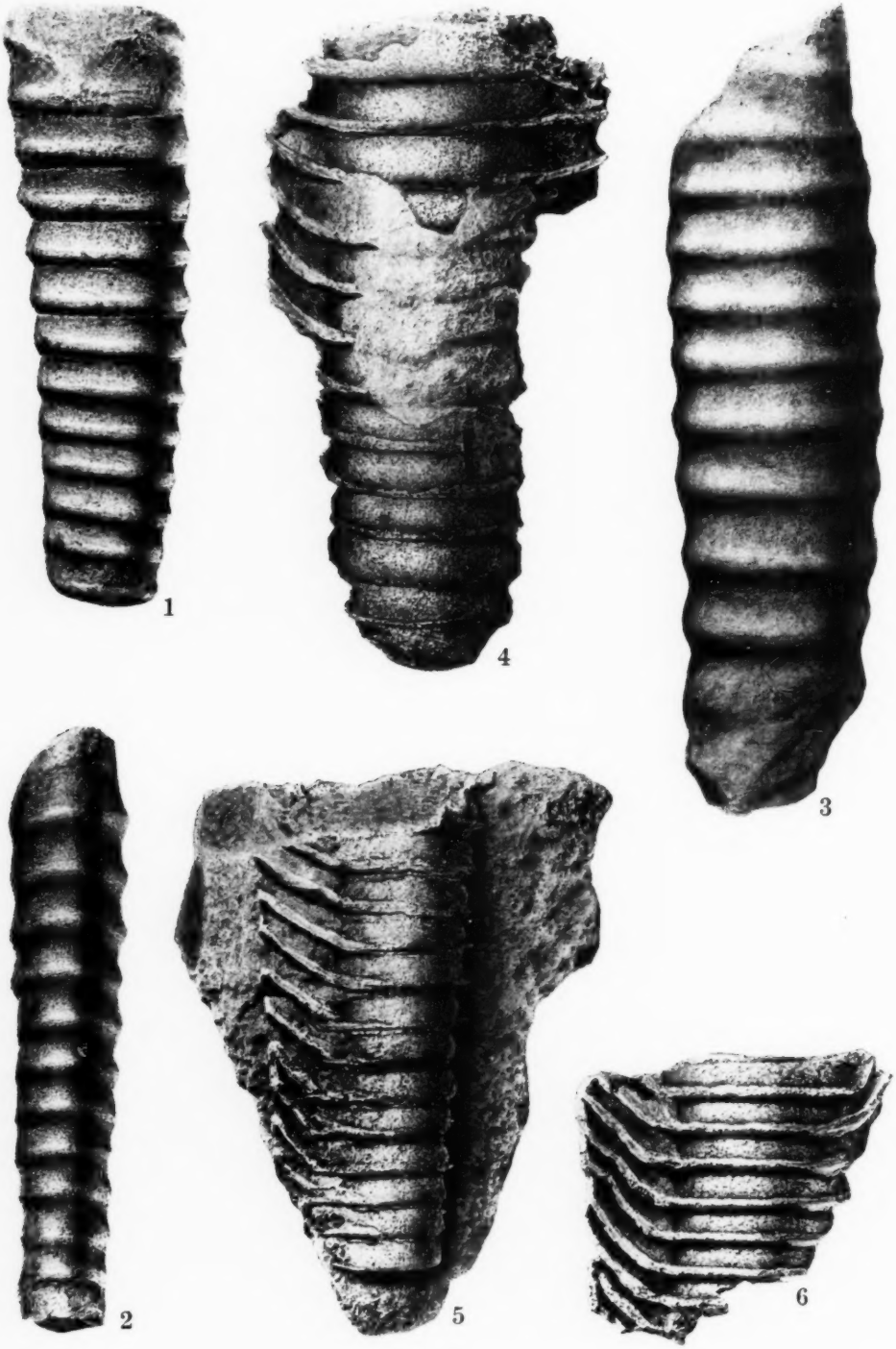
3–5—*Boreoceras parvulum* Miller and Youngquist, n. sp. Two of the syntypes—figures *4, 5* represent the same specimen—from Read Island, ×1. (p. 12)

6–8—*Boreoceras washburni* Miller and Youngquist, n. sp. Two of the syntypes; that represented by figures *6, 7* is from Sutton Island, that by figure *8* from Read Island; ×1. (p. 11)

9—*Halysites* sp. A specimen from Sutton Island, ×1. See also fig. *3*, pl. 1; and figs. *1, 2*, pl. 2. (p. 5)



Miller and Youngquist, Ordovician Fossils



Miller and Youngquist, Ordovician Fossils

annulations is about one-third the longer diameter of the conch. These annulations are very narrowly rounded, and therefore they appear to be considerably smaller than the intermediate grooves, which are broadly rounded.

On both specimens, internal molds, there are faint suggestions of longitudinal lirae, and a fragment of the test that is preserved on the smaller specimen indicates that these are all of about the same size and are slightly less than 1 mm. apart.

The length of the camerae is approximately equal to the distance between successive annulations. For the most part, the sutures are located in the adoral portions of the concave spaces between the annulations, but in the anterior portion of our smaller specimen they are located near the center of these grooves. Being straight and directly transverse, the sutures are parallel to the annulations. The septa are only slightly convex apicad.

The adapical end of the smaller of our two specimens is formed by a septum (or an impression of one), and on it there is a structure that appears to represent the siphuncle. It is small, circular in cross section, and subcentral in position but it is somewhat nearer the convex than the concave side of the conch.

Remarks.—When Foerste and Savage established this species, they based it primarily on a specimen that is depressed dorsoventrally, but they referred to it two specimens that are compressed laterally. Two of the three syntypes are stated to be curved longitudinally, whereas the third is straight. Presumably our specimen is closest to Foerste and Savage's laterally compressed curved individual (Foerste and Savage, 1927, pl. 5, fig. 3), in which, however, the annulations are somewhat more closely spaced than are those on the specimens under consideration.

Although our two specimens represent different parts of the conch, there seems to be every reason to regard them as conspecific. Foerste and Savage interpreted their species rather broadly, and our specimens appear to fall within its limits.

Occurrence.—All three of Foerste and Savage's type specimens came from the Shamattawa limestone near the southwestern shore of Hudson Bay. Both of ours are from Sutton Island.

Repository.—University of Alberta.

DISCOCERAS? sp.
Plate 5, figure 4

The only coiled nautiloid in the collections under consideration seems to be an aberrant type. This specimen is septate throughout, and it is about 66 mm. in diameter. One side of it is weathered, but the whorls, which are in contact but are not impressed dorsally, appear to be considerably higher than wide and to be elliptical (or possibly oval) in cross section.

The surface of the specimen bears prominent transverse ribs, of which there are about 20 in the adoral half volution. These ribs form broad, shallow, rounded lateral sinuses and apparently rather deep ventral salients. They appear to be about equally prominent on the lateral and ventral zones of the conch. No trace of additional ornamentation of the test can be observed.

Although none of the sutures is evident, the shape of the preserved portions of the septa indicates that the sutures are probably more or less parallel to the ribs. At the adoral end of the specimen there is a small structure near the venter that may represent the siphuncle.

Remarks.—The more distinctive characters of this form seem to be the rather gradually expanding whorls of the conch and the prominent ribs, which form ventral salients. Many early Paleozoic coiled nautiloids bear ribs, but in all of the cases that we have observed, the ribs are either straight

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EXPLANATION OF PLATE 8

FIGS. *1–3*—*Gorbyoceras* cf. *G. geronticum* (Foerste and Savage). Two internal molds—figures *1*, *2*, represent the same specimen—from Sutton Island, ×1. (p. 14)

4–6—*Armenoceras* spp. Three specimens from Sutton Island, ×1. See also figs. *1*, *2*, pl. 4; figs. *1–3*, *5*, *6*, pl. 5; fig. *8*, pl. 6; figs. *1*, *2*, pl. 7; and figs. *1–6*, pl. 9. (p. 16)

and directly transverse or they form ventral sinuses. Those of the genotype of *Discoceras* form rather prominent ventral sinuses, and the reference of our specimen to that species is tentative.

Occurrence.—The specimen under consideration came from Sutton Island, probably from float. It is composed of light-gray dolomite.

Repository.—University of Alberta, 547.

ARMENOCERAS spp.
Plate 4, figures 1, 2; plate 5, figures 1–3, 5, 6; Plate 6, figure 8; plate 7, figures 1, 2; plate 8; figures 4–6; plate 9, figures 1–6

The great majority of the cephalopods in the collections we are studying are actinoceratoid siphuncles to which, in some cases, portions of the septa and the test adhere. According to Foerste (1929, p. 202) the chief difference between *Actinoceras* and *Armenoceras* is that in the latter there are no

> distinct septal necks, both the overlying and the underlying connecting rings being adnate to the intermediate septa for a considerable width in the area immediately surrounding the passage of the siphuncle through the septa.

Actually, as Foerste and Teichert (1930, p. 208) later recognized, in *Armenoceras* there are "very short septal necks with abruptly recurved brims." Or, as stated by Flower (1946, p. 519),

> *Armenoceras* is differentiated from *Actinoceras* by the segments of the siphuncle, which are more abruptly expanded, so that the brim is well developed and the neck very short. The brim is sometimes free and sometimes recumbent, that is, so recurved as to lie in contact with the free part of the septum of which it is a modified continuation, and all gradations between the two conditions exist. The segments are expanded within the camerae, rounded, and generally the adapical end of the connecting ring is adnate to the septum.

The Arctic specimens that we are studying seem to possess the characters of *Armenoceras*, rather than those of *Actinoceras* or any of the other closely related genera. They reveal a considerable amount of variation and accordingly are believed to represent several species. Because of their incompleteness, it is difficult if not impossible to ascertain their specific affinities.

Our best specimen (pl. 4, figs. 1, 2), which is from Sutton Island, is an internal mold of the ventral part of a phragmacone, including the siphuncle. This specimen is about 123 mm. long, and its maximum width measures about 67 mm. It shows that the conch is rather gradually and regularly expanded orad, and that the internal mold is smooth. The sutures appear to form broad, shallow, rounded ventral lobes, which suggest that the ventral side of the conch may have been flattened. The length of the camerae of this specimen, measured along the venter, averages approximately 9⅓ mm. The siphuncle is ventral in position, but it is not quite in contact with the ventral wall of the conch. It is nummuloidal in structure, as its segments are greatly expanded within the camerae. Each segment appears to be in contact for a considerable distance with both of the septa adjacent to it. The maximum diameter of the preserved portion of the siphuncle is about 30 mm.

The specimen represented by figures 5 and 6 on plate 5, which is also from Sutton Island, preserves a similar portion of the conch as the one just described, but its camerae are shorter and its siphuncle larger. The over-all length of this specimen measures about 50 mm. and its maximum width about 54 mm. The length of its camerae, measured along the venter, averages approximately 8 mm. The siphuncle attains a maximum width within the adoral camera of about 31 mm. In structure and position, this siphuncle resembles very closely that of our best specimen (pl. 4, figs. 1, 2).

Figures 1–3 on plate 5 illustrate a fragment of a large siphuncle, which again has an armenoceratoid structure and is from Sutton Island. This specimen is about 54 mm. long, and its maximum width measures about 49 mm. As shown by figure 3 on this plate, there is inside this specimen a large endosiphuncular structure that is subcircular in cross section and is essentially cylindrical in form. This endosiphuncular structure is believed to be the same as the weathered cylindrical specimen represented by figure 8 on plate 6. This latter specimen, which is from the same locality, is about 64 mm. long and 23 mm. in diameter.

A single cephalopod was found in the float

on a small island about 1 mile northwest of Read Island (pl. 7, figs. 1, 2). It is an internal mold of the ventral portion of a phragmacone, and it resembles rather closely the specimens illustrated by figures 1 and 2 on plate 4 and figures 5 and 6 on plate 5. However, its camerae are relatively shorter—their length, measured along the venter, averages only about 5½ mm. The over-all length of this specimen is about 75 mm. and the maximum width about 45 mm.

Figures 4–6 on plate 8 represent three more specimens from Sutton Island. They serve to illustrate variations in the size and the shape of the siphuncular segments and in the length of the camerae in these forms. Also, they make it clear that specific determinations are not practicable.

The same considerations apply to the four Sutton Island specimens figured on plate 9. However, figures 1, 2, and 6 on this plate show portions of the test. Also, figure 4 shows an endosiphuncular structure which is not comparable to that shown by figure 3 on plate 5 and which may be adventitious.

The collections contain 12 congeneric specimens from Sutton Island. All of these are fragmentary internal molds of siphuncles and none seems to merit illustration or description.

Remarks.—In the drift on the shore of one of the small inland lakes on Liston Island, an Eskimo found a nautiloid which he gave to F. Ray Ross. This specimen is a weathered internal mold of eight segments of a siphuncle that appears to belong in *Armenoceras* but not to be conspecific with any of the other specimens under consideration. Its over-all length measures about 130 mm. and its maximum width about 41 mm.

Occurrence.—All but two of the specimens discussed above are from dolomite on Sutton Island, probably from float. The individual illustrated by figures 1 and 2 on plate 7 is from the float on a small island about 1 mile northwest of Read Island, and it also is preserved in dolomite. One of the unfigured specimens is from dolomite float on Liston Island.

Repository.—University of Alberta (Sutton Island specimens); and Yale Peabody Museum, 17329 (pl. 7, figs. 1, 2), 17331 (Liston Island specimen).

REFERENCES

BILLINGS, ELKANAH, 1860, New species of fossils from the Lower Silurian rocks of Canada: Canadian Naturalist and Geologist, vol. 5, pp. 161–177.

COX, IAN, 1936, Revision of the genus *Calapoecia* Billings: Canada Dept. Mines, Nat. Mus. Canada Bull. 80, pp. 1–49, pls. 1–4.

FLOWER, R. H., 1946, Ordovician cephalopods of the Cincinnati region, Part I: Bull. Am. Paleontology, vol. 29, no. 116, pp. 1–656, pls. 1–50.

FOERSTE, A. F., 1926, Actinosiphonate, trochoceroid, and other cephalopods: Denison Univ. Bull., vol. 26, no. 6 (Sci. Lab. Jour., vol. 21), pp. 285–383, pls. 32–53.

——, 1929, The cephalopods of the Red River formation of southern Manitoba: Denison Univ. Bull., vol. 29, no. 7, (Sci. Lab. Jour., vol. 24), pp. 129–235, pls. 11–39.

——, 1932, The cephalopod genera *Cyrtendoceras* and *Oelandoceras:* Ohio Jour. Sci., vol. 32, pp. 163–172, pls. 1, 2.

——, 1932, Black River and other cephalopods from Minnesota, Wisconsin, Michigan, and Ontario (Part I): Denison Univ. Bull., vol. 32, (Sci. Lab. Jour., vol. 27), pp. 47–136, pls. 7–37.

——, AND SAVAGE, T. E., 1927, Ordovician and Silurian cephalopods of the Hudson Bay area: Denison Univ. Bull., vol. 27, no. 3 (Sci. Lab. Jour., vol. 22), pp. 1–107, pls. 1–24.

——, AND TEICHERT, CURT, 1930, The actinoceroids of east-central North America: Denison Univ. Bull., vol. 30, (Sci. Lab. Jour., vol. 25), pp. 201–296, pls. 27–59.

GRABAU, A. W., AND SHIMER, H. W., 1909, North American index fossils, Invertebrates, vol. 1, pp. 1–853.

HYATT, ALPHEUS, 1900, [Tetrabranchiate] Cephalopoda, *in* Zittel-Eastman, Text-book of palaeontology, vol. 1, pp. 502–592. [In the second edition of this volume, published in 1913, the discussion of the Nautiloidea is reprinted (pp. 583–616) essentially without revision.]

KIRK, EDWIN, 1927, Review of "An Upper Ordovician fauna from the Rocky Mountains, British Columbia," by Alice E. Wilson: Jour. Geology, vol. 35, pp. 286–288.

KNIGHT, J. B., 1941, Paleozoic gastropod genotypes: Geol. Soc. America Special Papers 32 pp. 1–510, pls. 1–96.

LESLEY, J. P., 1889–1890, A dictionary of the fossils of Pennsylvania and neighboring states named in the reports and catalogues of the Survey: Pennsylvania Geol. Survey Rept. P 4, vols. 1–3, pp. 1–1283. [Vols. 1 and 2 (pp. 1–914) were issued in 1889, vol. 3 (pp. 915–1283) in 1890.]

LOGAN, W. E., *et al.*, 1863, Geology of Canada: Canada Geol. Survey Rept. Progress to 1863, pp. 1–983.

MILLER, A. K., 1932, The cephalopods of the Bighorn formation of the Wind River Mountains of Wyoming: Connecticut Acad. Arts and Sci. Trans., vol. 31, pp. 193–297, pls. 1–31.

O'NEILL, J. J., 1924, The geology of the Arctic coast of Canada; west of the Kent Peninsula: Canadian Arctic Exped. 1913–18, Rept., vol. 11, Geology and Geography, Pt. A, pp. 1–107, pls. 1–35.

SHIMER, H. W., AND SHROCK, R. R., 1944, Index fossils of North America, pp. 1–837, pls. 1–303.

TEICHERT, CURT, 1930, Die Cephalopoden-Fauna der Lyckholm-Stufe des Ostbaltikums: Paleont. Zeitschr., Band 12, pp. 264–312, pls. 5–9.

——, 1937, Ordovician and Silurian faunas from Arctic Canada: Fifth Thule Exped. 1921–24, Rept., vol. 1, no. 5, pp. 1–169, pls. 1–24.

TROEDSSON, G. T., 1926, On the Middle and Upper Ordovician faunas of northern Greenland, I, Cephalopods: Medd. om Grønland, Bd. 71, pp. 1–157, pls. 1–65. [Also issued as Comm. paléont., no. 25, Mus. Min. et Géol. Univ. Copenhague.]

——, 1928, On the Middle and Upper Ordovician faunas of northern Greenland, II: Medd. om Grønland, Bd. 72, pp. 1–197, pls. 1–56. [Also issued as Comm. paléont., no. 30, Mus. Min. et Géol. Univ. Copenhague.]

ULRICH, E. O., 1911, Revision of the Paleozoic systems: Geol. Soc. America Bull., vol. 22, pp. 281–680, pls. 25–29.

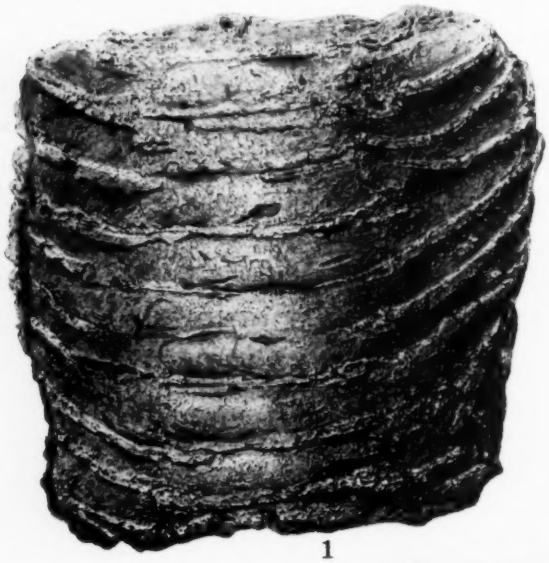
——, AND SCOFIELD, W. H., 1897, The Lower Silurian Gastropoda of Minnesota: Minnesota Geol. and Nat. History Survey, vol. 3, pt. 2, pp. 813–1081, pls. 61–82.

WASHBURN, A. L., 1947?, Reconnaissance geology of portions of Victoria Island and adjacent regions, Arctic Canada: Geol. Soc. America Mem. (in press).

WHITFIELD, R. P., 1900, Observations on and descriptions of Arctic fossils: Am. Mus. Nat. History Bull., vol. 13, pp. 19–22, pls. 1, 2.

WILSON, A. E., 1926, An Upper Ordovician fauna from the Rocky Mountains, British Columbia: Canada Geol. Survey Bull. 44, pp. 1–34, pls. 1–8.

——, 1931, Notes on the Baffinland fossils collected by J. Dewey Soper during 1925 and 1929: Roy. Soc. Canada Trans., ser. 3, vol. 25, sec. 4, pp. 285–308, pls. 1–5.



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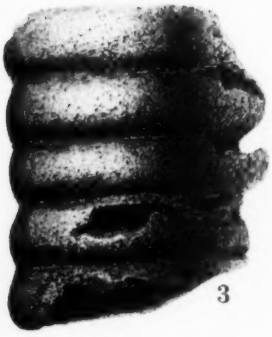

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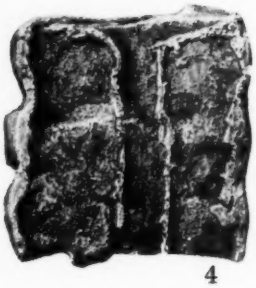

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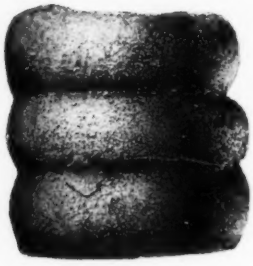

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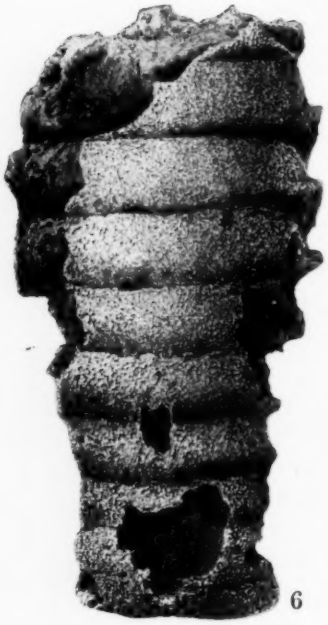

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UNIV. OF ILLINOIS

Miller and Youngquist, Ordovician Fossils

JOURNAL OF PALEONTOLOGY, VOL. 21, NO. 1, PP. 19–22, PL. 10, 3 TEXT FIGS, JANUARY 1947

A GONIATITE FROM THE MISSISSIPPIAN BOONE FORMATION OF MISSOURI

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ABSTRACT—The genus *Beyrichoceras* is discussed; and a new species, *B. hornerae*, is established for a unique specimen from the lower part of the Boone formation (Osage group) of southwestern Missouri.

LOCALLY ammonoids are abundant in the Kinderhook, Meramec, and Chester portions of the Mississippian system in North America, but few indeed have been found in the Osage group. The Fern Glen formation of southwestern Illinois has yielded the only known representative of *Imitoceras pfefferae* Miller and Werner. Several specimens that probably belong in the genus *Munsteroceras* are known from the Burlington limestone of Missouri, which immediately overlies the Fern Glen (Miller, 1935). Butts (1917, p. 14; 1922, p. 57) indicates that he found one or two goniatites of uncertain affinities in the New Providence shale of Kentucky and Indiana, which is the approximate stratigraphic equivalent of the Fern Glen and the Burlington formatons, but which may also include beds of Kinderhook age. The Cuyahoga group of Ohio and the lower portion of the Price sandstone of southwestern Virginia, which carry *Protocanites lyoni* (Meek and Worthen) and a few other ammonoids, are regarded by some authors as belonging in the Osage group, but at least the ammonoid-bearing beds of them should most probably be placed in the Kinderhook. Insofar as I have been able to ascertain, no other goniatites have been recorded from the Osage, and therefore the discovery of a well-preserved unique specimen in the Boone formation of southwestern Missouri merits attention.

This Boone specimen belongs in *Beyrichoceras* Foord (1903), which has not been recognized previously in America. In 1924 Bisat designated as its genotype *Goniatites obtusus* Phillips (fig. 1, this paper) of the upper part of the Pendleside limestone at Black Hall in Bolland (and probably also at Dinckley on River Ribble), England. Foord and Crick (1897, p. 169) and Foord (1903, p. 163) indicate that this specific name is a synonym of *Ellipsolites ovatus* Sowerby, which has priority and which is the genotype of *Nautellipsites* Parkinson. Sowerby's illustration and description leave so much to be desired that I am not able to confirm or reject this conclusion. However, Sowerby's figured type specimen, which came from Blackrock, Cork County, Ireland, and which is stated by Foord and Crick to be in the Sowerby Collection at the British Museum (Natural History), should be restudied with the point in mind that, even if the type specimens of these two genotypes are not conspecific, they may well be congeneric, in which case *Beyrichoceras* will have to be suppressed as a synonym of *Nautellipsites*. Meanwhile, it will probably be best to use the generic name *Beyrichoceras* rather than *Nautellipsites*, which has priority. Spath (1934, p. 15) has indicated that *Beyrichoceras* should be suppressed as a synonym of *Glyphioceras* Hyatt, but the type species of *Glyphioceras* is *Goniatites crenistria* Phillips, which is so similar to the genotype of *Goniatites* that many authors have considered it conspecific with that form. Therefore *Glyphioceras* should be suppressed as a

EXPLANATION OF PLATE 9

FIGS. *1–6*—*Armenoceras* spp. Four specimens from Sutton Island—figures *1*, *2*, represent the same specimen, as do figures *4*, *5*, ×1. See also figs. *1*, *2*, pl. 4; figs. *1–3*, *5*, *6*, pl. 5; fig. *8*, pl. 6; figs. *1*, *2*, pl. 7; and figs. *4–6*, pl. 8. (p. 16)

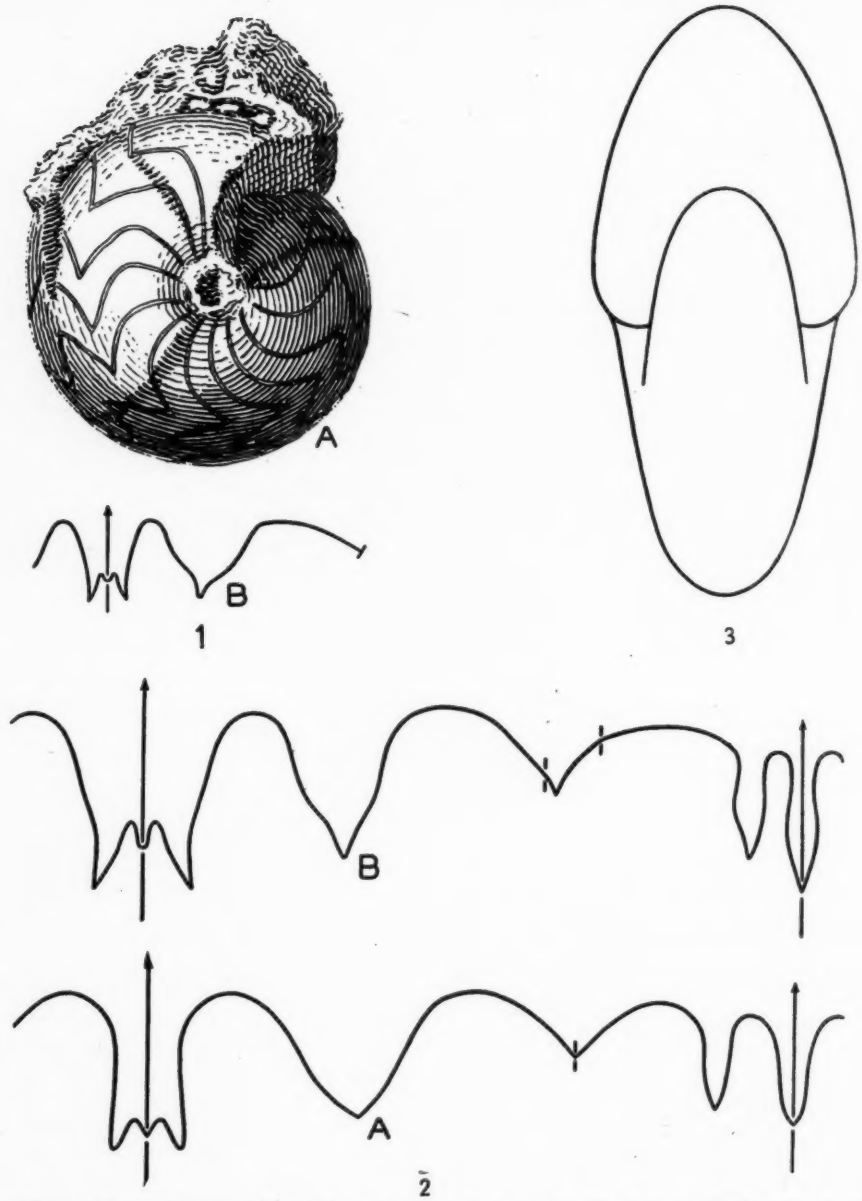


FIG. *1*—*Beyrichoceras obtusum* (Phillips). Holotype: *A*, lateral view, ×2, after Phillips; *B*, suture drawing, ×3, adapted from Bisat; from the Pendleside limestone at Black Hall in Bolland, England.

2—Diagrammatic representations of sutures: *A*, *Munsteroceras parallelum* (Hall), based on a small specimen, ×3¾, redrawn from J. P. Smith; *B*, *Beyrichoceras horneri* Miller, n. sp., based on the holotype, ×1½, where the conch is some 33 mm. high.

3—*Beyrichoceras hornerae* Miller, n. sp. Outline ventral view of holotype, ×1, restored.

synonym of *Goniatites* de Haan.

As shown by the accompanying illustrations, the sutures of the Boone specimen are strikingly similar to those of the holotype of Phillips' species. In general, they resemble also those of the genotype of *Munsteroceras* Hyatt, *M. parallelum* (Hall) of the Rockford limestone (Kinderhook) of Indiana. However, in that form the sides of the ventral lobe are essentially parallel, whereas in the specimen under consideration they diverge orad. As has been noted by Schmidt, the shape of the ventral lobe of the sutures is the chief distinguishing character between *Beyrichoceras* and *Munsteroceras*, which are very close. *Beyrichoceras* also resembles *Beyrichoceratoides* Bisat, but according to Bisat it can be "distinguished by the more advanced character of the septa and greater compression of the whorls."

In Europe *Beyrichoceras* is characteristic of the Middle Viséan (Bisat's zone B and Schmidt's zone IIIα), and the zone of *Beyrichoceras* comes between the zone of *Pericyclus* and that of *Goniatites*. The parallelism with the occurrence of the Boone specimen is striking, for the only representative of *Pericyclus* known from America came from the Chouteau limestone (upper Kinderhook) of central Missouri, and *Goniatites* occurs in the Moorefield shale of Arkansas, which immediately overlies the Boone formation.

BEYRICHOCERAS HORNERAE Miller, n. sp.
Plate 10, figures 4–7; text figures 2B, 3

The single specimen on which this species is based is a well-preserved internal mold that elucidates the nature of both the external and the internal sutures as well as the shape of the conch. It is septate throughout and therefore represents only phragmacone. Its maximum diameter measures about 80 mm., and near its adoral end its conch is about 43 mm. high and 36 mm. (estimated) wide—the maximum width is attained just outside (ventrad of) the umbilical shoulders. The whorls are rather narrowly rounded ventrally, flattened (but nevertheless very broadly rounded) laterally, and rather deeply impressed dorsally—at the adoral end of the specimen the impressed zone is about 19 mm. deep.

The umbilicus is small, and the maximum diameter of that of the holotype is only some 12 mm. The umbilical shoulders are rounded and not very definite. The umbilical walls are steep and are approximately normal to the flattened lateral zones of the conch.

The camerae are moderate in length, and there are about seven of them in the adoral half-volution of the holotype. As shown by text figure 2B, each suture forms a large symmetrically but unequally trifid ventral lobe with flanks that diverge orad rather strongly, and on either side of it an asymmetrically U-shaped first lateral saddle, a large V-shaped acuminate first lateral lobe (which is not as deep as the ventral lobe), a broad, very broadly rounded second lateral saddle, a shallow pointed lobe on the umbilical shoulder, a broad, very broadly rounded, asymmetrical internal second lateral saddle, a deep, narrow, hastate internal lateral lobe, and a high, narrow, rounded internal first lateral saddle, which extends to the very deep, narrow, hastate dorsal lobe.

Remarks.—At least insofar as sutures are concerned, this species resembles closely the genoholotype of *Beyrichoceras*, *B. obtusum* (Phillips). However, the second lateral saddles of the external sutures in that species do not seem to be as evenly rounded as are those of the form under consideration.

This species could easily be confused with representatives of the genus *Munsteroceras*, which is widespread and abundant in the Kinderhook and occurs also in the Osage. The type species of that genus is *M. parallelum* (Hall) of the Rockford limestone of Indiana (pl. 1, figs. 1–3; text fig. 2A). Insofar as the general physiognomy of its conch and its umbilicus are concerned, it does not differ greatly from *Beyrichoceras hornerae* (though it is somewhat more broadly rounded ventrally). Also, the sutures consist of the same number of elements as do those of *B. hornerae*, and only the ventral lobes of the two forms are significantly different—in *M. parallelum* the flanks of the ventral lobe are essentially parallel, whereas in *B. hornerae* they are considerably diverged orad.

Occurrence.—Mr. Lloyd G. Henbest of the U. S. Geological Survey has supplied the following data:

The holotype was found in a chert boulder,

about 25 cm. across, that was embedded in the creek bed in the NE. ¼ NW. ¼ SE. ¼ sec. 33, T. 23 N., R. 27 W., Cassville quadrangle, Barry County, Missouri. This locality is 1.47 miles S. 30′ E. from the county courthouse in Cassville. The stream and its headwaters flow on exposures or on residuum from the lower part of the Boone formation. Though the exact source of the specimen is not determinable, the lithology of the matrix and the field evidence indicate that it came from the lower part of the Boone formation, but not as low as the St. Joe limestone member, which is the basal unit of the Boone. The age is probably lower Burlington.

This specimen was found by Mrs. Ethel H. Horner, an amateur collector at Cassville, who has generously made it available for description and permanent preservation.

The specific name is given in honor of the collector.

Holotype.—Yale Peabody Museum 17112.

REFERENCES

BISAT, W. S., 1924, The Carboniferous goniatites of the north of England and their zones: Yorkshire Geol. Soc. Proc., n. ser., vol. 20, pt. 1, pp. 40–124, pls. 1–10.

——, 1936, The faunal stratigraphy and goniatite phylogeny of the Carboniferous of western Europe, with notes on the connecting links with North America: 16th Internat. Geol. Cong. Rept., United States 1933, pp. 529–537, table 1.

BUTTS, CHARLES, 1917, Descriptions and correlation of the Mississippian formations of western Kentucky: Kentucky Geol. Survey, Mississippian formations of western Kentucky, pp. 1–272, pls. 1–11.

——, 1922, The Mississippian series of eastern Kentucky: Kentucky Geol. Surv., ser. 6, vol. 7, pp. 1–188, pls. 1–81.

FOORD, A. H., 1903, Monograph of the Carboniferous Cephalopoda of Ireland, Part 5, containing the families Glyphioceratidae (concluded) and Prolecanidae . . . : Palaeontographical Soc., vol. 57, pp. 147–234, pls. 40–49.

——, and CRICK, G. C., 1897, Catalogue of the fossil Cephalopoda in the British Museum (Natural History), Part 3, containing the Bactritidae and part of the suborder Ammonoidea, pp. 1–303.

MILLER, A. K., 1935, Burlington goniatites: Am. Jour. Sci., ser. 5, vol. 30, pp. 432–437.

PHILLIPS, JOHN, 1836, Illustrations of the geology of Yorkshire . . . , Part 2, The Mountain limestone district, pp. 1–253, pls. 1–25.

SCHMIDT, HERMANN, 1925, Die carbonischen Goniatiten Deutschlands: Preuss. geol. Landesanstalt Jahrb. für 1924, Band 45, pp. 489–609, pls. 19–26.

SMITH, J. P., 1903, The Carboniferous ammonoids of America: U. S. Geol. Survey Mon. 42, pp. 1–211, pls. 1–29.

SOWERBY, JAMES, 1812, The mineral conchology of Great Britain . . . , vol. 1, pp. 1–234, pls. 1–102.

SPATH, L. F., 1934, Catalogue of the fossil Cephalopoda in the British Museum (Natural History), Part 4, The Ammonoidea of the Trias, pp. 1–521, pls. 1–18.

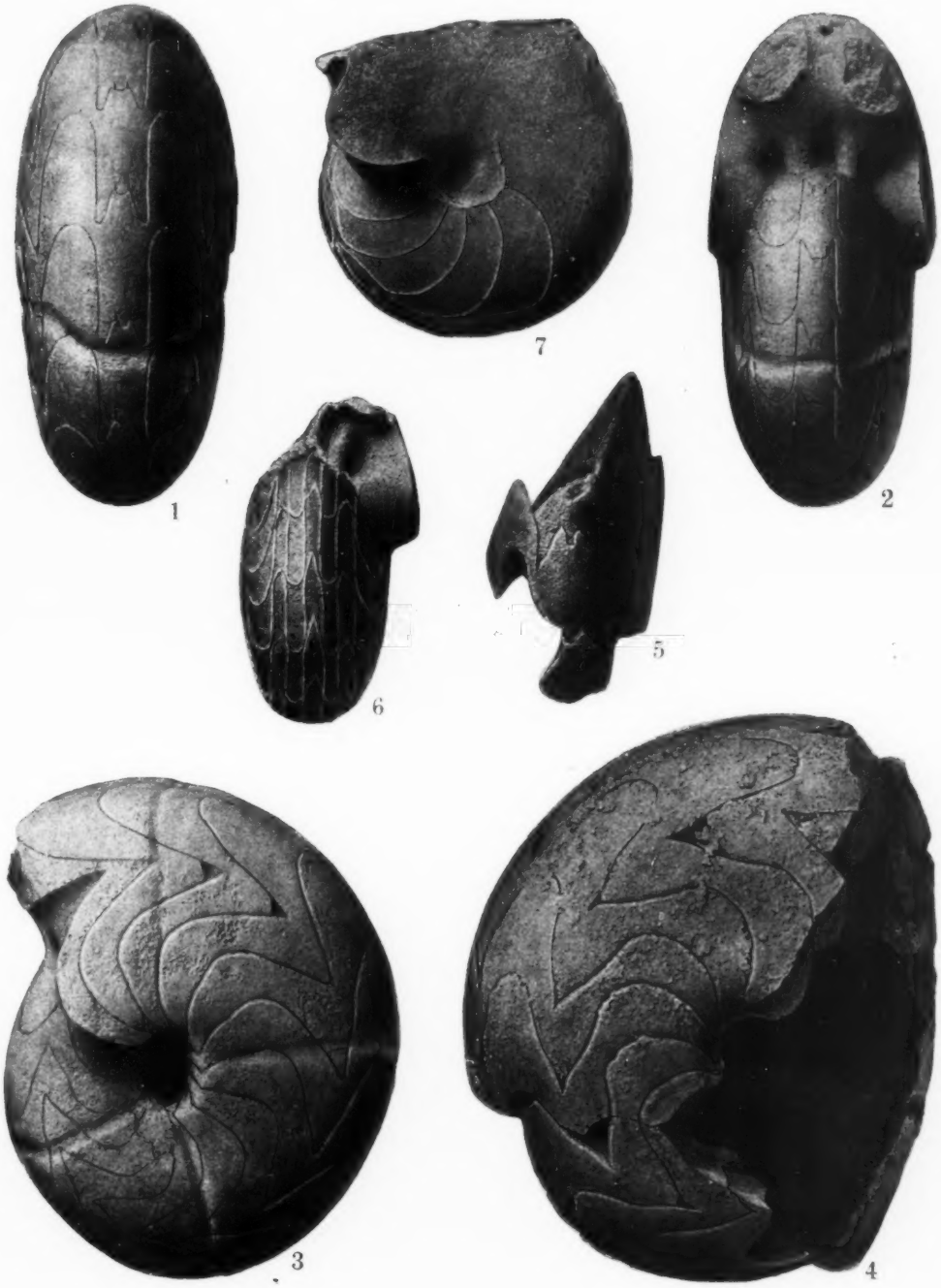
MANUSCRIPT RECEIVED JULY 30, 1945.

EXPLANATION OF PLATE 10

The illustrations on this plate are photographs retouched by Lee and Mary Allen. The artificial internal mold (figs. 6, 7) was prepared by Professor Homer R. Dill.

FIGS. *1–3*—*Munsteroceras parallelum* (Hall). Three views of a well-preserved but slightly distorted internal mold (State Univ. Iowa, 1086) from the Rockford limestone of Rockford, Indiana, ×2. (p. 21)

4–7—*Beyrichoceras hornerae* Miller, n. sp. Figure *4*, represents most of the holotype; *5*, is a ventral view of part of the specimen illustrated by *4;* and *6, 7* represent an artificial internal mold of the same specimen, showing the shape of the internal sutures; from the Boone formation near Cassville, Missouri; all ×1. (p. 21)



Miller, Mississippian Goniatites

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INVERTEBRATE FOSSILS FROM DEEP WELLS ALONG THE ATLANTIC COASTAL PLAIN

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ABSTRACT—The invertebrate fossils from oil tests and water wells along the Atlantic Costal plain between New Jersey and Georgia used in 1945 in an attempt to correlate the subsurface formations are here listed. The new or little-known species are described and figured. The list includes 38 Pleistocene species, 46 (3 new) Pliocene, 208 (7 new) Miocene, 35 (2 new) Eocene, and 20 (5 new) Upper Cretaceous. Four species are described in collaboration with Anne Harbison.

For the past three years the writer has been engaged in a study of the macrofossils from deep wells along the Atlantic Coastal Plain between New Jersey and Florida. This project was aided by a grant from the Penrose Bequest of the Geological Society of America. A report on the subsurface stratigraphy of some 190 wells has now been published (Richards, 1945). The evidence for the correlations used in that report was largely based upon a study of the macrofossils, especially mollusks. Because of space limitations full lists were not given in the previous report. This paper lists many of the species from these wells with descriptions or notes on the new and little-known forms.

Not all the species are listed in this paper; many are still unstudied. However, it is thought that enough have been studied to confirm those correlations cited in the previous paper. Since this work is still in progress, it is hoped to prepare a supplemental list at some future time.

ACKNOWLEDGMENTS

For a discussion of the organization of the project and for full acknowledgments, see Richards (1945, p. 885–6). Special mention should be given to the following, for assistance in the field and in obtaining specimens, Meredith E. Johnson, D. J. Cederstrom, M. J. Mundorff, Winnie McGlamery, and Captain Garland Peyton; for help in determinations, H. A. Pilsbry, B. F. Howell, Richard A. McLean, L. W. Stephenson, K. V. Palmer and Julia Gardner, in laboratory work Helen Shoemaker, and Anne Harbison. Four of the new species were described in collaboration with Anne Harbison, to whom due credit is given in the text. Finally, sincere thanks are given to the Geological Society of America for making this study possible.

LIST OF WELLS

For a full list of wells, together with elevations and logs, see Richards (1945). The following is an abbreviated list of those wells from which species are cited in this paper:

New Jersey

1. Asbury Park, Monmouth County.
2. Jacksons Mills, Ocean County.
8. Fort Dix, Burlington County.
10. Ancora, Camden County.
14. Parvin Park, Salem County.
15. Shiloh, Cumberland County.
16. Millville, Cumberland County.
18. Atlantic City, Atlantic County.
19. Ocean City, Cape May County.
20. Avalon, Cape May County.
21. Wildwood, Cape May County.
22. Rio Grande, Cape May County.
23. Cape May, Cape May County.
29. Brandywine Lighthouse in Delaware Bay.

A. Brigantine, Atlantic County.
B. Cape May Court House, Cape May County.
C. Sea Isle City, Cape May County.

Delaware

3. Dover, Kent County.
4. Lewes, Sussex County.
5. Bridgeville, Sussex County.

Maryland

2. Denton, Caroline County.
5. St. Michaels, Talbot County.
7. Cambridge, Dorchester County.
9. Salisbury, Wicomico County (Ice House).
11. Pocomoke City, Worcester County.
12. Ocean City, Worcester County.
14. Crisfield, Somerset County.

15. Salisbury, Wicomico County (Ohio Co.'s L. G. Hammond).

Virginia

1. Old Point Comfort, Elizabeth City County.
2. Fort Monroe, Elizabeth City County.
3. Newport News, Warwick County.
4. Norfolk, Norfolk County.
6. Lake Prince Nansemond County.
7. Drivers, Nansemond County.
8. Portsmouth, Norfolk County.
9. Yorktown, York County.
10. Fort Eustis, Warwick County.
11. Camp Peary, York County (several wells).
12. Bacon's Castle, Surry County (several wells).
13. Franklin, Southampton County (two wells).
13a. Franklin Airport.
15. Surry, Surry County.
17. Rieds Ferry, Nansemond County.
19. New Point Comfort, Matthews County.

North Carolina

4. Lewiston, Bertie County.
7. Elizabeth City, Pasquotank County.
9. Harvey Neck, Perquimans County.
10. Hertford, Perquimans County.
11. Edenton, Chowan County (Naval Base; several wells).
12. Williamston, Martin County.
18. New Bern, Craven County.
19. Cherry Point, Craven County (Marine Base; several wells).
20. Havelock, Craven County.
21. Morehead City, Cartaret County.
22. Fort Macon, Cartaret County.
23. Bogue, Cartaret County.
24. Atlantic, Cartaret County.
25. Cape Lookout, Cartaret County.
27. Kinston, Lenoir County.
28. Kinston Airport, Lenoir County (two wells).
30. Pollocksville, Jones County.
31. Jacksonville, Onslow County.
34. Camp Lejeune, Onslow County.
35. Sears Landing, Onslow County.
37. Top Sail Inlet, Pender County.
38. Wilmington Bomber Base, New Hanover County (three wells).
39. Wilmington Housing Authority (two wells).
40. Wilmington Water Works, New Hanover County.

South Carolina

6. Moncks Corners, Berkeley County.
11. Charleston, Charleston County.
12. Fort Moultrie, Charleston County.
13–5. Parris Island, Beaufort County.

Georgia

1. Savannah, Chatham County.
2. Cherokee Hill, Chatham County.
3. Fort Screven, Chatham County.
5. Camp Stewart, Liberty County.
6. Blackbeard Island, McIntosh County.
7. St. Simons Island, Glynn County.
8. Brunswick, Glynn County.
9. Brunswick Naval Air Station, Glynn County.
17. St. Mary's, Camden County.
19. Valdosta, Lowndes County.
20. Thomasville, Thomas County.
26. Albany, Dougherty County.
27. Sealy Well, 7 miles west of Albany, Dougherty County.

Alabama

1. Near Clayton, Barbour County (Hinton-Creel).
2. Near Clayton, Barbour County (Stebinger).
3. Near Bladen Springs, Choctaw County (McCorvey No. 1).
4. Scotch Lumber Co., Clarke County.

Florida

2. Jacksonville, Duval County.
11. U.S.G.S. Well 11, 17 miles west Boca Raton, on Hillsboro Canal, Palm Beach County.

LIST OF SPECIES

It should be pointed out again that this list is not complete and that additional species remain to be studied. Those mollusks from New Jersey wells described or listed in two recent papers (Richards and Harbison, 1942, 1943) are included in this list since new records are added from some of these wells.

The well number is in *italics* and follows the state abbreviation. When more than one well was studied from a locality, the individual well designation follows the well number (*6–3*). The depth is given in feet from top of well. When depth is not known, the symbol x is used.

PLEISTOCENE SPECIES

All late Pleistocene (Talbot, Pamlico or Cape May) unless otherwise indicated.

Pelecypoda

Anomia simplex d'Orbigny. N.J. *18*, 80–5; Del. *3*, 40; N.C. *25*, 75–101.
Arca transversa Say. N.J. *22*, 86–193; N.C. *22*, 15; *25*, 75–101; S.C. *15*, 31–5; Ga. *9*, 33–97.
Arca ponderosa Say. Ga. *9*, 53–69.
Cardium robustrum Solander. N.C. *23*, 30–45.
Cardium mortoni Conrad. Ga. *7*, 28–40.
Chione cancellata (Say). N.C. *21*, 20–30; *22*, 15; S.C. *15*, 31–5.
Corbula contracta Say. N.C. *24*, 20–30.
Donax variabilis Say. N.C. *24*, 20–30; *37*, 7–15.
Donax fossor Say. Ga. *8*, x.
Dosinia elegans (Conrad). N.C. *22*, 15.
Ensis directus (Conrad). Del. *3*. 40–50.
Gemma gemma (Totten). N.J. *23*, 62–70.
Leda acuta (Conrad). N.C. *22*, 15; Ga. *7*, 28–40.
Mulinia lateralis (Say). N.J. *22*, 86–171; Del. *3*, 40–50; N.C. *19*, 25; *23*, 30–45; *24*, 20–30; Va. *4*, 45; S.C. *15*, 11–76; Ga. *3*, 90–158.
Nucula proxima Say. Ga. *9*, 129–34.
Nucula major Richards (1944) (pl. 12, figs. 1, 2) From excavations for the Cape May Canal,

New Jersey. Probably of late Pleistocene age (Wisconsin).
Ostrea virginica Gmelin N.J. *18*, 80–5; N.C. *37*, 7–15; S.C. *15*, 31–5; Ga. *3*, 90–158; *9*, 69–74.
Pecten gibbus irradians Lamarck, N.J. *18*, 80–5; N.C. *19*, 10.
Phacoides crenella Dall. N.C. *22*, 15.
Strigilla flexuosa (Say). S.C. *15*, 38–76.
Rangia cuneata (Gray). N.J. *23*, 90; Va. *4*, 125.
Venericardia tridentata Say. N.C. *22*, 15.
Venus mercenaria Linné. N.J. *22*, 51; N.C. *35*, 20.
Yoldia limatula (Say). N.J. *22*, 86–116.

Gastropoda

Acteocina canaliculata (Say). N.J. *22*, 86–106; N.C. *22*, 15.
Columbella lunata Say. N.C. *22*, 15.
Columbella obesa Adams. Ga. *3*, 90–158; *9*, 69–74.
Crepidula plana Say. N.C. *19-52*, 25; S.C. *15*, 31–5.
Crepida fornicata (Linné). N.C. *37*, 7–15.
Fulgur canaliculata (Say). N.J. *18*, 80–5.
Nassarius obsoleta (Say). N.J. *18*, 80–5; S.C. *15*, 31–5.
Nasarrius trivittata (Say). N.J. *22*, 51; *18*, 80–5; Del. *3*, 40–60.
Neritina virginea Lamarck. N.C. *24*, 20–95.
Olivella mutica (Say). N.C. *15*, 30; *19-52*, 25; *22*, 15; Ga. *3*, 90–103.
Polinices duplicata (Say). Del. *3*, 70.
Seila adamsi Lea. Ga. *9*, 69–74.
Terebra dislocata (Say). N.C. *22*, 15.
Turbonilla conradi Bush. N.J. *22*, 106.

PLIOCENE SPECIES

All Waccamaw or Croatan formations unless otherwise indicated.

Pelecypoda

Abra aequalis (Say). N.C. *9*, 54.
Aligena sp. N.C. *11-7*, 31–40.
Arca transversa Say. N.C. *8*, 65–70; *9*, 43–82; *11-1*, 40–7; *11-4*, 41–5; *11-8*, 8–30; *19-1*, 65; *19-4*, 140; *19-52*, 25; *24*, 90–5.
Arca improcera Conrad. N.C. *11-7*, 8–30.
Corbula swiftiana Adams. (pl. 11, figs. 20, 21). N.C. *9*, 74–82.
Corbula inaequalis mansfieldi Richards. (pl. 11, figs. 27, 31). n. subsp. N.C. *9*, 43–57.
Crasinella lunulata (Conrad). N.C. *9*, 54–7; *24*, 90.
Ensis directus (Conrad). N.C. *11*, 34–60.
Glycymeris americana (De France). N.C. *11-3*, 38–46.
Leda acuta (Conrad). N.C. *9*, 43–65; *19-52*, 25–64.
Mactra similis Say. N.C. *9*, 54–7.
Mactra soladissima Dillwyn. N.C. *9*, 46–54; *24*, 90.
Modiolus ducatelli Conrad (pl. 12, fig. 14). N.C. *25*, 75–101.
Mulinia congesta Conrad. S.C. *16*, 38–76.
Mulinia lateralis (Say). N.C. *7*, 65–70; *9*, 54–65; *11-1*, 40–7; *24*, 90–5.
Mulinia sapotilla (Dall). N.C. *24*, 20–30.
Nucula proxima Say. N.C. *9*, 54–7.
Ostrea compressirostra Say. N.C. *9*, 43–6 (?).
Ostrea sculpturata Conrad. N.C. *9*, 55–7; *11-1*, 38–40; *11-4*, 37–41; *25*, 75–101.
Ostrea virginica Gmelin. N.C. *9*, 46–57; *11-4*, 41–5.
Phacoides crenulatus (Conrad). N.C. *11-1*, 47–9; *11-3*, 38–46.
Phacoides multilineatus Tuomey and Holmes. N.C. *9*, 43–57.
Phacoides waccamawensis Dall. N.C. *9*, 43–6; S.C. *15*, 31–5.
Venericardia granulata Say. Ga. *17*, 60.
Venericardia tridentata Say. N.C. *9*, 43–54; *19*, 25–65; *24*, 20–90.
Venus campechiensis Gmelin. N.C. *9*, 55–7; *11-7*, 8–30.

Gastropoda

Acteocina canaliculata (Say). N.C. *9*, 43–6; *24*, 90.
Cithna pilsbryi Richards n. sp. (pl. 11, fig. 17). N.C. *11-5*, 34–46.
Columbella avara Say. N.C. *9*, 43–6.
Columbella lunata Say. N.C. *7*, 65–70; *9*, 43–57; *24*, 95.
Columbella obesa Adams. N.C. *9*, 43–6; *19-52*, 25.
Conus parkeri Richards and Harbison (pl. 11, figs. 1–4). n. sp. Fla. *11*, 47–50.
Crepidula convexa Say. N.C. *7*, 65–70; *24*, 90–5.
Crepidula fornicata (Linné). N.C. *7*, 65–70; *9*, 43–6; *24*, 90–5.
Crucibulum costatum (Say). N.C. *24*, 90.
Fulgur canaliculata (Say). N.C. *9*, 43–6.
Nassarius obsoleta (Say). N.C. *11-3*, 38–46.
Nassarius trivittata (Say). N.C. *7-3*, 65–70; *25*, 75–101. Pleistocene or Pliocene.
Odostomia sp. N.C. *9*, 46.
Olivella mutica (Say). N.C. *9*, 43–82; *11*, 40–5; *19-25*, 25.
Polinices duplicata (Say). N.C. *9*, 43–54.
Terebra dislocata Say. N.C. *24*, 90–5.
Terebra protexta Conrad. N.C. *9*, 55–7; *19-1*, 65.
Turritella subanulata Heilprin. N.C. *9*, 55–7; *19-1*, 65.
Urosalpinx cinerea (Say). N.C. *9*, 43–57; *24*, 90.

Coelenterata

Astrangia danae Agassiz. N.C. *25*, 75–101.

MIOCENE SPECIES

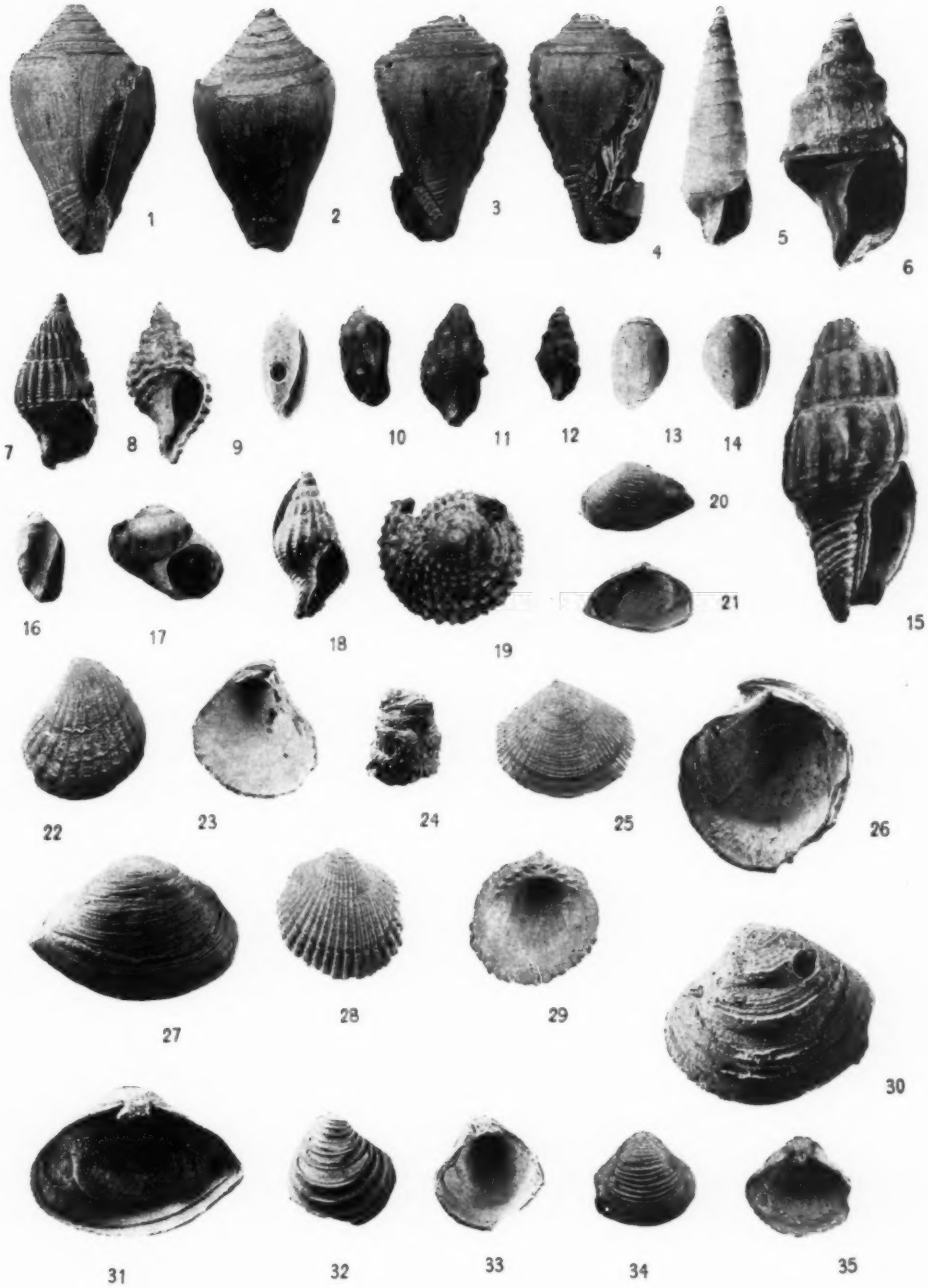
All Middle or Late Miocene unless otherwise indicated.

Anomia simplex d'Orbigny. N.J. *B*, 520; Va. *1*, 220; N.C. *12*, 60–70.
Antigona staminea (Conrad). N.J. *B*, 520; *C*, 768–85; Md. *18*, 840–50.
Arca staminea Conrad. N.J. *18*, x; *29*, 485–97.
Arca subrostrata Conrad. N.J. *18*, x; *29*, 372–631.
Arca transversa Say. N.J. *29*, 400–631; Va. *12*, 35; Ga. *9*, 180–96. Not hitherto reported from Miocene.
Arca improcera Conrad. N.J. *29*, 372–555 (?); Va. *12*, 35.
Arca improcera var. Ga. *8*, 510–25.
Arca incile Say. Va. *6*, 35.
Arca lienosa Say. N.J. *18*, x.
Arca idonea Conrad. N.J. *18*, x; *29*, 372; Md. *14*, 135.
Arca millvillensis Richards and Harbison. N.J. *16*, 580.

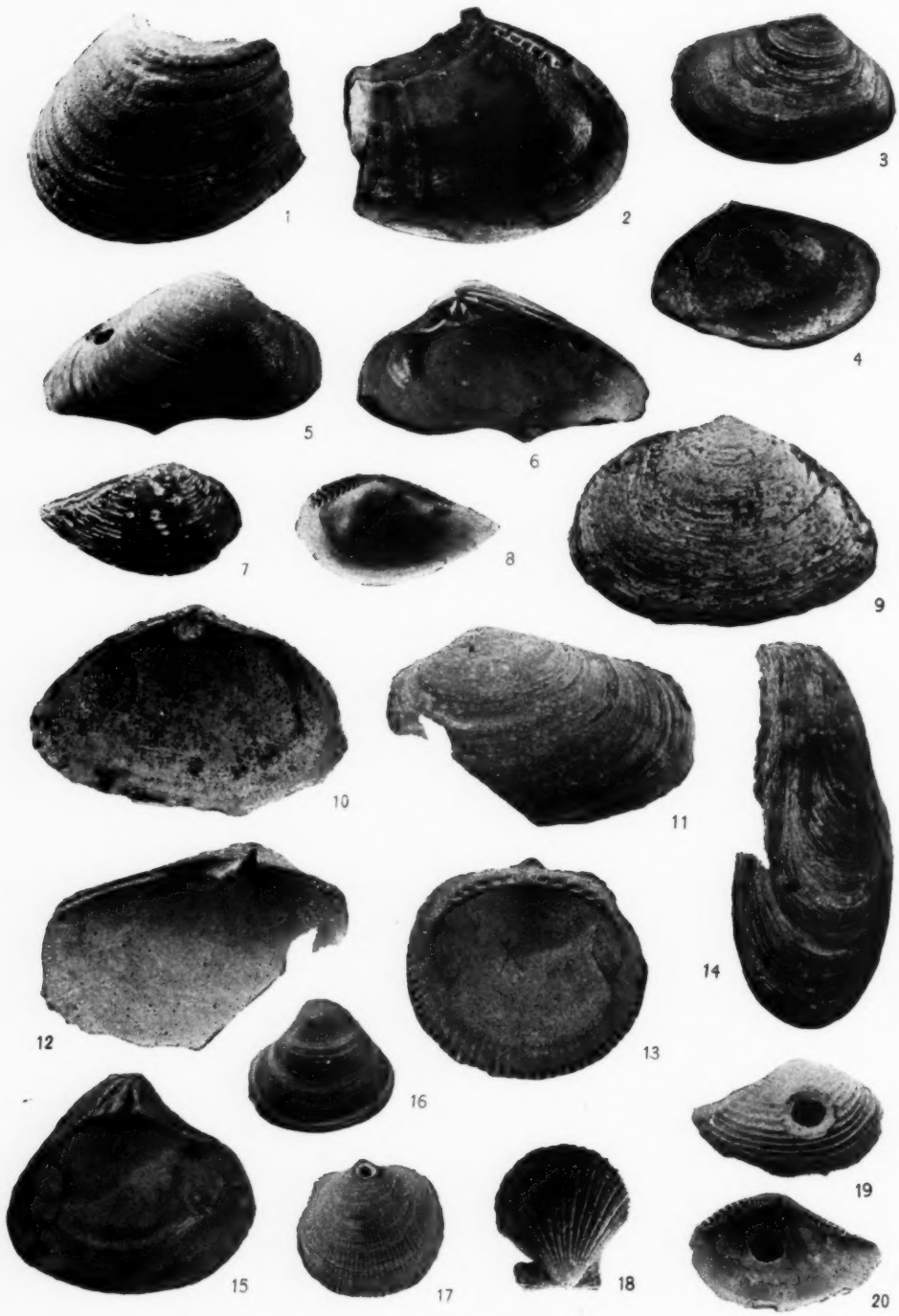
Arca triginitaria Conrad. Va. *12*, 115.
Arca adamsi Smith. N.C. *19-52*, 60.
Asaphis centenaria Conrad (pl. 11, fig. 25). Va. *12*, 35–115.
Astarte distans Conrad. N.J. *14*, 95; *18*, 555–727; *19*, 595–730; *21*, 694–900; *23*, x; *29*, 298–631; *B*, 520; *C*, 600–800.
Astarte perplana Conrad. N.J. *18*, x; *29*, 220–316; N.C. *19-15*, 130.
Astarte undulata Say. N.J. *23*, 550; *29*, 308; Md. *14*, 190; Va. *1*, 120; *6*, 250–325; *9*, 70–90; *11*, 285–300; *12*, 35–214; *15*, x; N.C. *19-15*, 140.
Astarte undulata vaginulata Dall. N.J. *29*, 260–485.
Astarte concentrica Conrad. N.C. *11-5*, 72.
Astarte concentrica Bella Conrad. Va. *12*, 35–80; N.C. *11*, 35–47.
Astarte cuneiformis Conrad. N.J. *18*, x; Va. *12*, 214.
Astarte exaltata Conrad. Va. *15*, x.
Astarte mundorffi Richards and Harbison (pl. 12, figs. 15, 16). n. sp. N.C. *23*, 130.
Astarte sp. (pl. 11, fig. 30). N.C. *24*, 140.
Astarte sp. (pl. 11, figs. 32, 33). Va. *12*, 99.
Callista neusensis Harris (pl. 13, fig. 23). N.C. *18*, 80 (Trent).
Callocardia sp. N.J. *10*, 290–300.
Cardita arata (Conrad). N.J. *18*, x; *19*, 730; *21*, 411–4; *29*, 400; Va. *12*, 35.
Cardium laqueatum Conrad. N.J. *29*, 400–97; *C*, 600–700; Md. *18*, 390–420; Va. *1*, 100–200.
Cardium patuxentium Glenn. N.J. *29*, 308–497; Md. *18*, 490–500.
Chama congregata Conrad. N.J. *18*, 730–8; Md. *18*, 630–40; Va. *12*, 35–120; *9*, 50–80; *15*, x; N.C. *19-1*, 65.
Chama corticosa Conrad (pl. 11, fig. 24). Va. *12*, 120.
Chione latilirata (Conrad) (pl. 13, figs. 12, 13). N.J. *21*, 673–707; *29*, 480–5; Va. *1*, 170.
Corbula elevata Conrad. N.J. *18*, 727–1200; *20*, x; *23*, 810; *C*, 600–700; N.C. *19*, x.
Corbula ima Pilsbry and Harbison. N.J. *C*, 600–700.
Corbula inaequalis Say. N.J. *18*, 385, 1200; *21*, 673–94; *23*, 370–80, 980; *19*, 365–85; Del. *4*, 384; Md. *7*, 75; Va. *1*, 100; *6*, 35, 460; N.C. *11*, 40–60; *19*, 150–60.
Corbula idonea Conrad. N.J. *18*, x; *29*, 308–631; Va. *11*, 270–90.
Corbula chipolana carolina Richards, n. var. (pl. 11, figs. 34, 35). N.C. *23*, 130.
Crassinella nansemondensis Gardner juv. (pl. 13, figs. 8, 9). Del. *3*, 300; N.C. *11*, 52–60.
C. lunulata (Conrad) (pl. 13, figs. 6, 7). Va. *6*, 35; *8*, 60; *12*, 55, 68; N.C. *19-4*, 50; *23*, 175.
C. lunulata harrisi Gardner (pl. 13, figs. 4, 5). Va. *8*, 60.
C. duplinanum Dall (pl. 13, figs. 10, 11). N.J. *10*, 290–300; *21*, 705–13; N.C. *19-4*, 140.
C. profundorum Pilsbry and Harbison, N.J. *18*, 727; *19*, 730; *20*, x; *21*, 411–4; *29*, 499–505; *C*, 600–700.

Explanation of Plate 11

Figs. *1–4*—*Conus parkeri* Richards and Harbison, n. sp. ×1, Near Boca Raton, Fla., 47–50 feet, USNM 559928 (type 1, 2) (p. 32)
5—*Terebra simplex* Conrad. ×1, Salisbury, Md., 420–30 feet, ANSP 16798 (p. 29)
6—*Melanopsis quadrata* Conrad. ×2, Salisbury, Md., 430–40 feet, ANSP 16797 (p. 28)
7, 11—*Nassarius peralta* (Conrad. *1*, ×2, Salisbury, Md., 330–40 feet, ANSP 16796; ×4, Atlantic City, N. J., 860–70 feet, ANSP 16766. (p. 29)
8—*Urosalpinx?* sp. ×4, Edenton, N.C. 72 feet, ANSP 16770. (p. 29)
9—*Acteocina cederstromi* Richards, n. sp. ×4, Bacons Castle, Va. 115 feet, ANSP 16771 (type). (p. 34)
10—*Acteocina chowanensis* Richards, n. sp. ×4, Edenton, N.C. 46–58 feet, ANSP 16754 (type). (p. 34)
12—*Mangilia parva* (Conrad). ×4, Edenton, N.C., 72 feet, ANSP 16749. (p. 28)
13–14—*Cypraeolina dacria* Dall. ×3½, Edenton, N.C., 72 feet, ANSP 16758. (p. 28)
15—*Anachys clappi* Mansfield?. ×4, Bacons Castle, Va., 99 feet, ANSP 16752 (p. 28)
16—*Olivella mutica* (Say). ×2, Lewes, Del., 985 feet, ANSP 16751. (p. 29)
17—*Cithna pilsbryi* Richards, n. sp. ×10, Edenton, N. C., 34–46 feet, ANSP 16769(type). (p. 32)
18—"*Fasciolaria*" *parvula* Lea. ×4, Bacons Castle, Va., 85 feet, ANSP 16746. (p. 28)
19—*Calliostoma ruffini* (Lea). ×4, Bacons Castle, Va., 35 feet, ANSP 16763. (p. 28)
20–21—*Corbula swiftiana* Adams. ×2, Harvey Neck, N.C., 74–82 feet, ANSP 16748. (p. 25)
22–23—*Glans perplanus* (Conrad). ×4, Bacons Castle, Va., 35 feet, ANSP 16760. (p. 27)
24—*Chama corticosa* Conrad. ×2, Bacons Castle, Va., 120 feet, ANSP 16739. (p. 26)
25—*Asaphis centenaria* (Conrad). ×3½, Bacons Castle, Va., 35 feet. (p. 26)
26—*Phacoides trisulcata albemarlensis* Richards, n. subsp. ×2, Edenton, N.C., 41–5 feet, ANSP 16772 (type). (p. 33)
27, 31—*Corbula inaequalis mansfieldi* Richards, n. subsp. ×1½, Harvey Neck, N.C., 43–6 feet, ANSP 16865 (type). (p. 32)
28, 29—*Glycymeris subovata plagia* Say. ×3½, Bacons Castle, Va., 115 feet, ANSP 16745. (p. 27)
30—*Astarte* sp. ×2, Atlantic, N.C., 140 feet, ANSP 16757. (p. 26)
32, 33—*Astarte* sp. ×2, Bacons Castle, Va., 99 feet, ANSP 16756. (p. 26)
34, 35—*Corbula chipolana carolina* Richards, n. var. ×4, Bogue, N.C., 140 feet, ANSP 16750 (type). (p. 33)



Richards, Fossils From Deep Wells



Richards, Fossils From Deep Wells

Cumingia medialis Conrad (pl. 12, figs. 9, 10). N.C. *11-4*, 60.
Crassatellites undualtus (Say). Va. *9*, 70–80; *11*, 140; N.C. *11-5*, 120.
Donax abseconi Richards and Harbison. N.J. *18*, x.
Dosinia acetabulum (Conrad). N.J. *18*, x; *23*, 611–8; *29*, 308–631; Md. *18*, 440–50; Va. *1*, 50–100; *6*, 460; N.C. *23*, 130.
Ensis directus (Conrad). N.J. *16*, 285; *19*, 595; *29*, 276–87; *B*, 520.
Ervillia sp. N.J. *23*, 400; Del. *3*, 1020–80; *C*, 785.
Eucrassatella melina (Conrad). N.J. *18*, x; *29*, 548–631; *B*, 520; *C*, 600–700.
Glans perplanus (Conrad) (pl. 11, figs. 22, 23). Va. *12*, 35.
Glycymeris parilis (Conrad). N.J. *16*, 420; *20*, x; *21*, 694–707; *29*, 480–631; *C*, 600–700; N.C. *19-4*, 160.
Glycymeris subovata (Say). N.J. *21*, 860–900 juv.—Va. *12*, 160; *15*, x; N.C. *11-3*, 72; *24*, 140.
G. subovata plagia Say (pl. 11, figs. 28, 29). Va. *12*, 115.
Glycymeris pectinata (Gmelin). Va. *12-2*, 68–99; N.C. *11-4*, 41–5; 23, 150.
Glycymeris boguensis Richards and Harbison n. sp. (pl. 12, figs. 13, 17). N.C. *23*, 130.
Leda acuta (Conrad) (pl. 12, figs. 7, 8). Md. *14*, 52–60; *18*, 390–450; Va. *1*, 100–10; *4*, 105; *6*, 35; *12*, 35; N.C. *11-3*, 46–58; *11-4*, 41–5; *11-5*, 72; *12*, 40–70; *24*, 140; *22*, 15; Ga. *7*, 28–40.
Leda concentrica (Say) (pl. 12, figs. 19, 20). Md. *11*, 53–63.
Leda liciata (Conrad). N.J. *23*, 980; *21*, 694–707; Md. *14*, 52–69.
Macrocallista acuminata Dall. N.C. *23*, 130. A Florida Miocene species; first record from North Carolina.
Macrocallista albaria (Say). N.C. *23*, 150.
Macrocallista maculata (Linné). N.C. *11*, 34–46 (Pliocene or Miocene); *19-4*, 146.
Macrocallista marylandica (Conrad). N.J. *16*, 410; *18*, x; *29*, 525–46; *B*, 520.
Macrocallista sp. (pl. 12, figs. 5, 6). N.C. *24*, 140.
Mactra insulaemaris Pilsbry and Harbison. N.J. *C*, 600–700.
Mactra clathrodon Lea. N.J. *19*, 385; *20*, 800–15; *21*, 840–1000; *23*, 600-40; *B*, 520; *C*, 600–700.
Mactra delumbis Conrad. N.J. *14*, 100; *16*, x; *18*, 936–41; *21*, 800–900; *C*, 600–700.
Melina maxillata (Deshayes) (pl. 13, fig. 17). N.J. *18*, 764–800; *B*, 520; *C*, 600–700; Md. *14*, 135; *18*, 630–70; Va. Lamberts Point, 616; N.C. *23*, 130. First record from Miocene of North Carolina.
Metis biplicata (Conrad). N.J. *16*, 310.
Modiolus inflatus (Tuomey and Holmes). Va. *12*, 200.
Mulinia congesta (Conrad). Va. *6*, 35–460; *9*, 50–60; *12*, 35–288; *15*, x; N.C. *10*, 100; *22*, 120–50; *19*, 65–140; *24*, 140; S.C. *15*, 38–76; Ga. *8*, 345.
Mulinia lateralis (Say). N.J. *10*, 290–300; *16*, 385; *18*, 656–727; *19*, 365–85; *27*, 694–947; *23*, 420–980; *29*, 385–631; Md. *18*, 340–420; N.C. *25*, 75–101; *23*, 130; Ga. *8*, 330; *9*, 174–80.
Mya producta Conrad. N.J. *29*, 230–400.
Mytilus conradinus d'Orbigny. N.C. *11-3*, 46–58; *19-4*, 150.
Mytilus incurvus (Conrad). N.J. *20*, 375; *B*, 520; *C*, 600–700.
Nucula proxima Say. N.J. *19*, 730; *18*, 727; *21*, 694–1000; *23*, 980; *29*, 480–5; Md. *18*, 330–500; Va. *1*, 170; *12*, 115; N.C. *12*, 50–70: *11*, 40–60; Ga. *9*, 129–34.
Ostrea compressirostra Say. Md. *18*, 590–600 (?); Va. *6*, 130–285; *15*, x; N.C. *11-5*, 276; *24*, 210.
Ostrea sellaeformis Conrad. Md. *18*, 590–610 juv.
Ostrea disparilis Conrad. Va. *1*, 170; *6*, 325.
Ostrea sculpturata Conrad. Va. *6*, 35; *12*, 35.
Ostrea cf. *thomasii* "Conrad" Martin. N.J. *10*, 290–300 (frag.).
Ostrea virginica Gmelin. N.J. *29*, 220–448.
Pecten madisonius Say. N.J. *10*, 272–80; *14*, 125; *18*, 656–94; *20*, 810; *21*, 694–1000; *23*, 600–40; *29*, 260–63; Del. *3*, 396–400; Md. *7*, 75; *18*, 510–730; Va. *1*, 90–270; *4*, 395; *6*, 130; *11*, 75–90; *12*, 90–198; N.C. *19*, 65–105; *22*, 70–80; *24*, 220.
Pecten clintonius Say. Va. *4*, 185.
Pecten irradians Lamarck, N.J. *16*, 344.
Pecten eboreus Conrad. N.J. *18*, x; *29*, 316–631; Md. *12*, 241–50; *18*, 630–40; Va. *12*, 90; *13-2*, 85; N.C. *9*, 43–57; *10*, 100; *11-4*, 60; *11-5*, 70–120; *12*, 60–70; *19-15*, 70, 95; *24*, 140, 210; *37*, 73–6; Ga. *9*, 174–80; *17*, 410.
Pecten humphrysii woolmani Heilprin. N.J. *23*, x.
Pecten jeffersonius Say. Md. *14*, 135; Va. *1*, 50–240; *4*, 85; *11*, 285–300; *12*, 80–247; N.C. *24*, 330; *25*, 125–77; *13-52*, 90; Ga. *8*, 330; *17*, 370.

EXPLANATION OF PLATE 12

FIGS. *1, 2—Nucula major* Richards. ×2, Cape May, N.J., ANSP 15938 (type). (p. 31)
3, 4—Tellina dupliniana Dall. ×4, Edenton, N.C., 40–7 feet, ANSP 16753. (p. 28)
5, 6—Macrocallista sp. ×2, Atlantic, N.C., 140 feet, ANSP 16774. (p. 27)
7, 8—Leda acuta (Conrad). ×4, Salisbury, Md., 440–50 feet, ANSP 16799. (p. 27)
9, 10—Cumingia medialis Conrad. ×3½, Edenton, N.C., 60 feet, ANSP 16773. (p. 27)
11, 12—Sphenia dubia (Lea). ×4, Cherry Point, N.C. 270 feet, ANSP 16747 (p. 28)
13, 17—Glycymeris boguensis Richards and Harbison, n. sp. ×2, Bogue, N.C. 130 feet, ANSP 16740 (type) (p. 33)
14—Modiolus ducatelli Conrad. ×4, Cape Lookout, N.C., 75–101 feet, ANSP 16744. (p. 25)
15, 16—Astarte mundorffi Richards and Harbison, n. sp. *15*, ×2, *16*, ×1, Bogue, N.C., 130 feet, ANSP 16741 (type); *16*, ×1. (p. 33)
18—Pecten seabeensis Richards, n. sp. ×2, Camp Peary, Va., 380 feet, ANSP 16781 (type). (p. 34)
19, 20—Leda concentrica (Say). ×4, Pocomoke City, Md., 53–63, feet, ANSP 16738. (p. 27)

Phacoides anodonta (Say). N.J. *29*, 276–87; *C*, 600–700; Va. *12*, 161.
Phacoides crenulatus (Conrad). N.J. *14*, 95; *16*, 215; *18*, 727; *19*, 374–595; *20*, 810; *21*, 411–900; *23*, 810, 980; *29*, 276–400; *B*, 500; Md. *14*, 190; *16*, 610–20; Va. *1*, 100–70; *6*, 35; 50–90; *12*, 90; N.C. *10*, 100; *11-5*, 60–90; *12*, 40–110; *19*, 140; *23*, 130–150.
Phacoides prunus Dall. N.J. *21*, 694–707; *C*. 600–700.
Phacoides trisulcatus (Conrad). Va. *1*, 50; N.C. *23*, 175–205.
Phacoides trisulcatus whitfieldi Dall. N.J. *16*, 385; *18*, x; *20*, x; *21*, 411–1000; *23*, x.
Phacoides trisulcata albemarlensis Richards, n. subsp. (pl. 11, fig. 26). N.C. *11*, 41–45.
Plicatula marginata Say. Va. *12*, 35.
Semele scintillata Dall. N.C. *23*, 130.
Sphinia dubia (Lea) (pl. 12, figs. 11, 12). N.C. *19-4*, 270.
Tellina declivis Conrad. N.J. *18*, x; *21*, 860–900; *23*, 825; *29*, 308; N.C. *11-4*, 88; Va. *6*, 35.
Tellina producta Conrad. N.J. *18*, x.
Tellina capilifera Conrad. N.J. *21*, 752.
Tellina (*Moerella*) *dupliniana* Dall (pl. 12, figs. 3, 4). N.C. *11-4*, 40–47.
Teredo sp. Va. *1*, 100.
Venericardia granulata Say. N.J. *18*, 656–941; *20*, 810; *21*, 800–1000; *23*, 780–1140; *29*, 613–31; *C*, 800–18; Md. *14*, 310; Va. *1*, 170; *6*, 35–370; *9*, 70–90; *11*, 75–90; *12-1*, 35–200; *12-2*, 68–115; *13-1*, 106–110; N.C. *11*, 31–58; *23*, 150.
Venericardia tridentata Say. N.C. *19-1*, 65 (Pliocene or Miocene).
Venus campechiensis Gmelin. N.C. *23*, 130.
Venus mercenaria Linné. N.J. *16*, 212–55; *21*, 411–618; *23*, 411; *29*, 220–631; *B*, 520; Va. *1*, 100–250; *2*, x.
Venus ducatelli Conrad. N.J. *C*, 600–700.
Venus rileyi Conrad. N.C. *23*, 150.
Yoldia laevis (Say). N.J. *29*, 276–87; Va. *1*, 50–60; *6*, 130; N.C. *12*, 50–60.

Gastropoda

Acteon ovoides Conrad. N.J. *C*, 600–700.
Acteocina canaliculata (Say). N.C. *11-5*, 72; *23*, 130. May have washed down from above.
Acteocina kirkwoodiana Richards and Harbison. N.J. *29*, 385.
Acteocina cederstromi Richards n. sp. (pl. 11, fig. 9). Va. *12*, 115.
Acteocina chowanensis Richards, n. sp. (pl. 11, fig. 10). N.C. *11-3*, 46–58.
Anachis clappi Mansfield (pl. 11, fig. 15). Va. *12*, 99.
Bulliopsis integra (Conrad). N.J. *21*, 611–8; *23*, 320–60, 460; *29*, 548–55. (St. Mary's formation).
Busycon tuberculatum (Conrad). N.J. *16*, 460.
Busycon scalarispira Conrad. N.J. *16*, 460; *B*, 520; *C*, 600–700.
Caecum sp. N.C. *11-7*, 52–60.
Calliostoma humilis (Conrad). N.C. *11-5*, 72.
Calliostoma eboreum (Conrad). N.J. *23*, 420–60.
Calliostoma ruffini (Lea) (pl. 11, fig. 19). Va. *12*, 120.
Calliostoma sp. N.J. *10*, 290–300.
Cancellaria shilohensis Pilsbry and Harbison. N.J. *16*, 460–70.
Cancellaria alternata Conrad. N.J. *21*, 840–80; *C*, 600–700.
Calyptraea aperta (Solander) (pl. 13, fig. 14). N.J. *14*, 125; *16*, 500–20; *18*, 873–941; *19*, 730; *20*, 810; *21*, 694–707; *29*, 613–31; *B*, 520; Md. *18*, 630–40; N.C. *23*, 130; *24*, 90–5; *39*, 124–7. All Yorktown except N.C. *39*, 124–7 which is Trent.
Cerithidea insulaemaris Pilsbry and Harbison. N.J. *C*, 600–700.
Cochiolepis sp. Va. *12*, 90.
Coralliophila cumberlandiana (Gabb). N.J. *16*, x; *C*, 600–700.
Crepidula aculeata (Gmelin). Va. *12*, 35.
Crepidula convexa Say. Va. *12*, 90.
Crepidula plana Say. N.J. *16*, 430.
Crepidula fornicata (Linné). N.J. *23*, 440; *29*, 385–400; *B*, 520; Md. *18*, 410–20; Va. *1*, 50–100; *12*, 35–100; *15*, x; N.C. *11*, 46–60.
Crucibulum costatum (Say). N.J. *16*, x; *20*, x; *23*, 820; *29*, 385–400; N.C. *11-5*, 72–90.
Cymatosyrinx pseudoburnea Heilprin. N.J. *23* 560.
Cymatosyrinx whitfieldi Martin. N.J. *C*, 600–700.
Cymia woodi (Gabb) (pl. 13, fig. 1, 2). N.J. *18*, 873–931. (*Fasciolaria woodi* Gabb. Richards and Harbison, 1942, p. 216).
Cypraeolina dacria Dall (pl. 11, figs. 13, 14). N.C. *11-5*, 72. Also reported from well at Elizabeth City, N.C. (Mansfield, 1939).
Drillia limatula (Conrad). Md. *18*, 410–20; Va. *1*, 80.
Eulima eborea Conrad. N.J. *29*, 400.
Ecphora tricostata Martin. N.J. *16*, x; *20*, 600–700; Va. *1*, 170–200.
"*Fasciolaria*" *parvula* Lea (pl. 11, fig. 18). Va. *12*, 85.
Fasciolaria sparrowi Emmons. N.C. *23*, 130.
Fissurella redimiculata Say. N.C. *19-50*, 118.
Fissurella griscomi Conrad. N.J. *19*, 730.
Fossarus dalli (Whitfield). N.J. *23*, 560.
Kurtziella precerina Pilsbry and Harbison. N.J. *19*, 515.
Lirosoma sulcosa (Conrad). Va. *12-1*, 90.
Mangilia parva (Conrad) (pl. 11, fig. 12). N.C. *11-5*, 72 (?).
Marginella bella (Conrad). Va. *12-2*, 200.
Marginella denticulata Conrad. Va. *12-1*, 140.
Marginella limatula Conrad. Va. *12*, 68–161.
Marginella virginianum Conrad (pl. 13, fig. 15). Va. *15*, x.
Melanopsis quadrata (Conrad) (pl. 11, fig. 6). Md. 18, 410–40 (St. Mary's).
Mitrella edenensis Richards and Harbison, n. sp. (pl. 15, fig. 6). N.C. *11-5*, 72.
Mitrella laevis (Whitfield). N.J. *18*, 730–8; *19*, 515, 730; *20*, x; *C*, 600–700.
Mitrella communis (Conrad). N.J. *29*, 385; Va. *12*, 35–68.
M. communis mediocris Pilsbry and Harbison. N.J. *C*, 730.
Murex millvillensis Richards and Harbison. N.J. *16*, 460–505.
Muricidea shilohensis (Heilprin). N.J. *C*, 600–700.

Nassarius acuta (Say). Ga. *9*, 525 (may have washed down from above).
Nassarius peralta (Conrad) (pl. 11, figs. 7, 11). N.J. *18*, 860–70; Md. *18*, 330–50; Va. *1*, 170–270. First record from New Jersey.
Nassarius bidentata (Emmons). N.J. *18*, 873–95; *20*, x.
Nassarius trivittatoides (Whitfield). N.J. *18*, 420–1010; *19*, 385–730; *20*, 815; *29*, 385; *B*, 520.
Nassarius sopora (Pilsbry and Harbison). N.J. *C*, 600–700.
Oliva sayana Ravenel. N.J. *20*, x,
Olivella mutica (Say) (pl. 11, fig. 16). Del. *3*, 985; Va. *1*, 50; N.C. 19–4, 140. The specimen from the Lewes, Del., well is very fresh in appearance and may have fallen from above. However, the species is not known from the Pleistocene or Recent of Delaware. The Cherry Point, N.C., specimen at 140 feet probably fell from above.
Polinices duplicata (Say). N.J. *16*, x; *18*, 873–95; *19*, 595–730; *20*, x; *21*, 694–707; *29*, 385–400; Md. *12*, 228; *18*, 330–40; Va. *1*, 50; *12*, 50–70; *11-4*, 41–5; *19-4*, 190.
Polinices heros (Say). N.J. *18*, x; *21*, 694–732; *23*, 820–980; *29*, 250–400; Md. *18*, 390–400; *14*, 190. Va. *1*, 80; *11*, 75–90; *12*, 99–161; N.C. *23*, 150.
Polinices hemicrypta (Gabb). N.J. *16*, 470; *18*, 873–95; *20*, x; *C*, 600–700.
Polinices triseriata (Say). N.J. *16*, x; Md. *18*, 360–70.
Rapana ecclisiastica Dall. N.J. *C*, 600–700.
Scalaria marylandica (Martin). N.J. *29*, 400; Del. 3, 568, 1020–80.
Seila clavulus (Lea). N.J. *19*, 730; *29*, 385; Va. *9*, 50–60.
Sinum fragile (Conrad). N.J. *B*, 520.
Siphonalia devexa (Conrad). N.J. *16*, 515; *C*, 600–700.
Siphonalia calvertana Martin. Md. *18*, 420–30 (?).
Solarium trilineatum Conrad. N.J. *A*, 621–51.
Teinostoma liparium (Lea). N.J. *18*, 860–70. First record from Miocene of New Jersey.
Teinostoma nanum (Lea). Va. *6*, 35.
Terebra whitfieldi Martin. N.J. *16*, 305; *23*, 320–60; *C*, 600–700.
Terebra simplex Conrad (pl. 11, fig. 5). Md. *18*, 420–30.
Terebra curvilirata Conrad. N.J. *19*, 515; Md. *18*, 330–440.
T. curvilineata calvertensis Martin. N.J. *20*, x.
Terebra inornata Whitfield. N.J. *18*, 873–95; *19*, 730; *23*, 320–60; *B*, 520; *C*, 600–700.
Terebra dislocata (Say). N.J. *29*, 558–631 (May have fallen from above).
Trigonostoma planasuturata Richards and Harbison. N.J. *16*, 460–70.
Turbonilla interrupta Totten. N.J. *23*, 810; *29*, 499–505; *B*, 520; Va. *6*, 35; N.C. *11-4*, 88; *11-5*, 72–90.
Turbonilla sp. Md. *18*, 330–40; Va. *1*, 50; *12*, 85; Ga. 7, 28–40.
Turritella aequistrata Conrad. N.J. *18*, 726–30; *19*, 385; *21*, 887–930; *23*, 780–1010; *29*, 372–631; *C*, 600–700.
Turritella alticosta Conrad. Va. *1*, 260.
Turritella plebia Conrad. N.J. *18*, 450; *19*, 515–730; *20*, x; Md. *14*, 328–30; *18*, 330–40; Va. *9*, 250–60; *12*, 80–100; *14*, 328–30.
Turritella secta Conrad. N.J. *16*, x; *18*, x; 21, 920–1000; *23*, 780–90.
Turritella variabilis Conrad. Md. *18*, 340–510; Va. *1*, 50–100; *2*, 120; *4*, 135; *6*, 35–325; *9*, 70–200; *10*, 502–22; *11*, x; *12*, 55–200; N.C. *11*, 38–72; *12*, 40–100; *19*, 60; *24*, 140, 210; *37*, 15–30.
Turritella cumberlandia Conrad. N.J. *18*, 936–41; *19*, 365–730; *20*, x; *21*, 673–930; *23*, 790; *29*, 230–631; *B*, 520; *C*, 600–700; Del. *3*, 396–568.
Urosalpinx? sp. (pl. 11, fig. 8). N.C. *11*, 72.
Vermetus graniferus Say. N.J. *B*. 520; *C*, 600–700; Va. *12*, 90–200.
Vermetus sculpturata Lea. Va. *8*, 35; *15*, x.
Volvula iota (Conrad). N.J. *B*, 520.

Scaphopoda

Cadulus conradi Pilsbry and Harbison. N.J. *19*, 730; *23*, 810–20; *29*, 276–400; *B*, 520.
Cadulus thallus (Conrad). Md. *18*, 650–60; Va. *1*, 50–260; *6*, 35–130; N.C. *9*, 100; *11-5*, 90; *23*, 130–75.
Dentalium attenuatum Conrad. Md. *18*, 410–20; *14*, 328–30; Va. *1*, 110–90; *4*, 135; *6*, 250–460; *12*, 99–300; *11*, 75–90; N.C. *12*, 60–70; Ga. *17*, 60.
Dentalium caduloide Dall. N.J. *21*, 752; *23*, 980; Md. *18*, 390–400; N.C. *11-5*, 72.

Brachiopoda

Discinisca lugubris (Conrad). N.J. *18*, x.

Coelenterata

Astrangia danae Agassiz. N.J. *C*, 600–700; N.C. *11*, 50; *19-1*, 65.

Crustacea

Balanus concavus Bronn. Va. *1*, 90–260; *11*, 140; N.C. *24*, 140.
Balanus spp. N.J. *29*, 308–497; Del. *3*, 568–1080; Md. *7*, 75; *14*, 345–765; *18*, 370–830. N.C. *11*. 49–60; *12*, 60–7; *23*, 130–50; *37*, 70–73.

Echinodermata

Echinarachnius sp. N.J. *B*, 520.

EOCENE SPECIES

Pelecypoda

Cardium sp. Ga. *1*, 640–70.
Crassinella sp. Va. *11*, 384–410.
Gryphaeostrea vomer (Morton) (pl. 13, fig. 18). Va. *6*, 427–460+; *11*, 375–9; *12*, 332; N.C. 12, 100 (Pamunkey). The specimens from the well at Williamston, N.C., mark the first record of Pamunkey deposits in North Carolina. The microfaunal evidence confirms the dating of this material as Middle Eocene.
Macrocallista sp. Ga. *8*, 960–75.
Nucula ovula Lea (pl. 13, fig. 20). Ga. *1*, 500–520. Cast of both valves; the dorsal valve is, slightly straighter than typical. Ocala formation.
Ostrea bryani Gabb. N.J. *7*, 50 (Manasquan-Shark River).
Ostrea sculpturata Conrad. Md. *2*, 360–91; *5*, 370 (Pamunkey).

Ostrea sellaeformis Conrad. N.C. *37*, 162–72 (Castle Hayne).
Ostrea divaricata Lea. Ga. *26–7*, 323–32 (Ocala).
Ostrea georgiana Conrad. Ga. *7*, 610–94. (Ocala)
Ostrea thirsae Gabb (pl. 13, fig. 19). Ala. *3*, 1000–8.
Pecten membranosus Morton. S.C. *15*, 76–155 (Santee)
Pecten cookei Kellum. Ga. *1*, 500–20 (Ocala).
Pecten ocalanum Dall. Ga. *8*, 780–1010 (Ocala).
Pecten sp. (pl. 13, fig. 3). Va. *13a*, 100–40. One broken shell which cannot be determined specifically.
Pecten seabeensis Richards, n. sp. (pl. 12, fig. 18). Va. *11*, 380.
Pecten delawarensis Richards and Harbison (pl. 13, fig. 24). N.J. *29*, 825. (Jackson).
Phacoides sp. Va. *12*, 344; Ga. *8*, 1040–63.

Gastropoda

Marginella sp. Va. *11*, 325–60.
Natica sp. Va. *11*, 384–410.
Scalaria virginica (Clark). N.J. *29*, 825 (Jackson).
Siphonalia? johnsoni Richards, n. sp. (pl. 14, fig. 24). N.J. *7*, 50.
Turritella mortoni Conrad. Va. *12*, 322, 394.
Turritella nasuta Gabb var. (pl. 13, fig. 16). Ala. *3*, 1400–20.
Turritella spp. Ga. *19*, 380–5; *20*, 420; *26–7*, 112–5
Urosalpinx sp. Ga. *8*, 55.

Scaphopoda

Cadulus turgidus Meyer (pl. 13, fig. 25). Ala. *3*, 1660–80.

Brachiopoda

Terebratula harlani Morton. Va. *1*, 840; *12*, 374 (Pamunkey).
Terebratulina atlantica (Morton). N.J. *1*, 280 (Hornerstown).

Coelenterata

Trochocyathus lunulitiformis Conrad (pl. 14, fig. 14). N.J. *18*, 950. This Jackson Eocene coral was identified by Dr. T. Wayland Vaughan from the Atlantic City well at a depth of 950 feet. This was obtained from a greensand which had formerly been regarded as the base of the Miocene (Richards and Harbison, 1942). It more probably is Eocene and equivalent to the Jacksonian deposits found in the Brandywine Lighthouse well (Richards, 1945, p. 897). Figured specimen: ANSP 16777.
Trochocyathus conoides Gabb and Horn. N.J. *7*, 50.

Bryozoa

Lunularia distans Lonsdale. S.C. *15*, 76–155.

(Other species not listed)

Crustacea

Solidobalanus sp. N.J. *29*, 825; Del. *5*, 780 (Jackson).

Annelida

Spirulaea rotula (Morton) (pl. 13, fig. 21). N.J. *1*. x; Va. *6*, 340–460. The specimen from the well at Lake Prince, Va., marks the first record south of New Jersey. According to Howell (personal communication) the species is an index fossil for the Vincentown = Upper Aquia.
Spirulaea mcglammeri (Gardner) (pl. 13, fig. 22). Va. *13a*, 100–40. According to Howell (personal communication) this is an index fossil of the Midway. Its presence in the well at Franklin, Va., is evidence for the presence of Midway deposits in subsurface Virginia. See Richards, 1945, p. 907.

UPPER CRETACEOUS SPECIES

Pelecypoda

Brachydondes salisburyensis (Richards) (pl. 15 fig. 2) Md. *18*, 1588–98.
Breviarca sp. Md. *18*, 1688–98.
Cardium penderense Stephenson (pl. 14, fig. 20) N.C. *38–1*, 105 (Peedee).
Corbula crassiplica Gabb (pl. 14 fig. 5). Ala. *2*, 1707–40. Referable to either the Eutaw or

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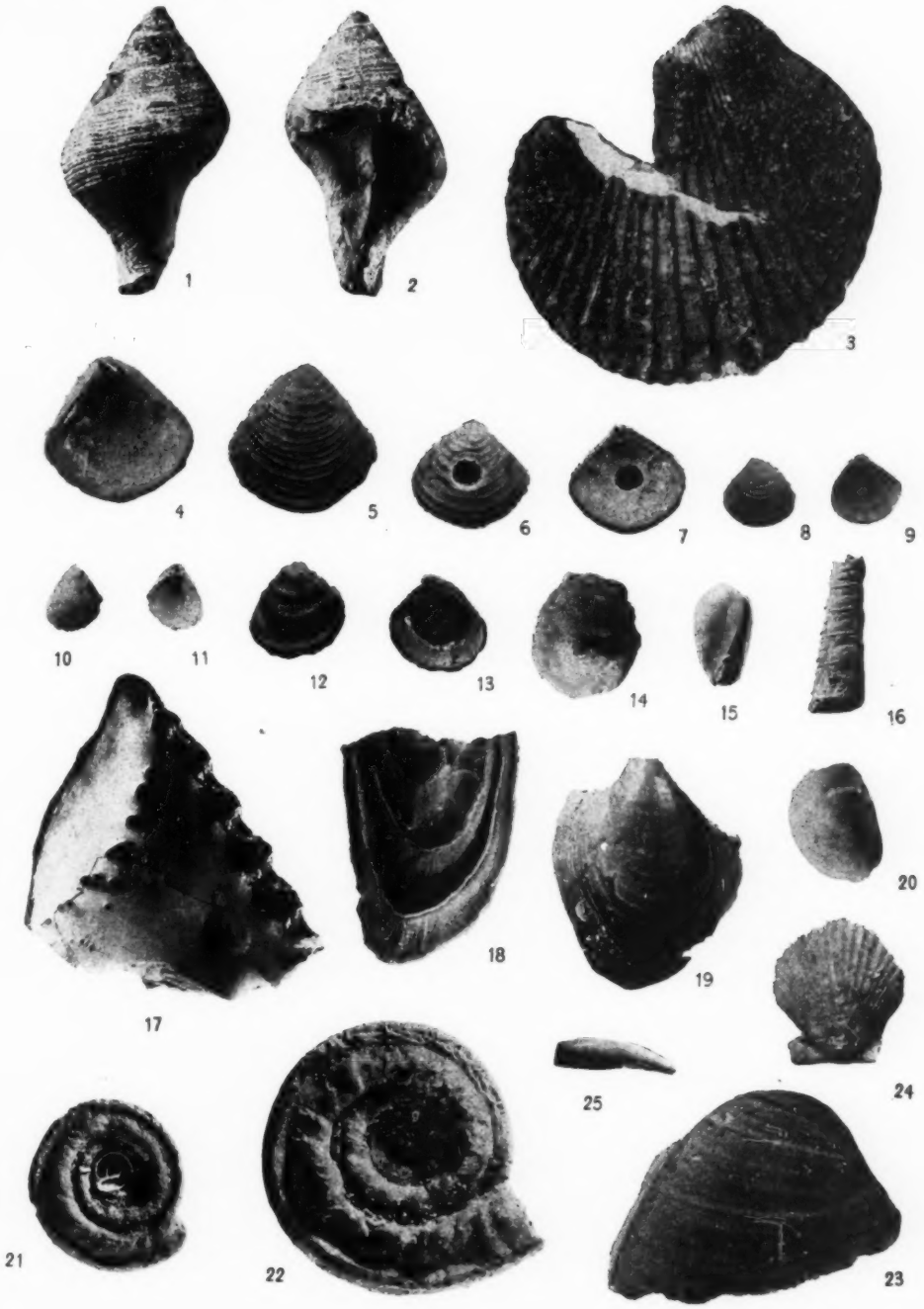
EXPLANATION OF PLATE 13

FIGS. *1, 2—Cymia woodi* (Gabb). ×1½, Shiloh, N.J., ANSP 14038, (p. 28)
3—Pecten sp. ×2, Franklin, Va., 100–40 feet, ANSP 16778. (p. 30)
4, 5—Crassinella lunulata harrisi Gardner. ×4, Portsmouth, Va., 60 feet, ANSP 16762. (p. 26)
6, 7—C. lunulata (Conrad). ×4. Bacons Castle, Va., 68 feet, ANSP 16755. (p. 26)
8, 9—C. nansemondensis Gardner. ×4, Dover, Del., 200 feet, ANSP 16759. (p. 26)
10, 11—C. duplinanum Dall. ×4, Cherry Point, N.C., 140 feet, ANSP 16767. (p. 26)
12, 13—Chione latilirata (Conrad). ×4, Wildwood, N.J., 694–707 feet, ANSP 16743. (p. 26)
14—Calyptraea aperta (Solander). ×2, Jacksonville, N.C., 124–7 feet, ANSP 16788. (p. 28)
15—Marginella virginianum Conrad. ×2, Surry, Va., depth?, ANSP 16768. (p. 28)
16—Turritella nasuta Gabb, var. ×2, Bladen Springs, Ala., 1400–20 feet, Ala. G.S. (p. 30)
17—Melina maxillata (Deshayes). ×2, Bogue, N.C., 130 feet, ANSP 16742. (p. 27)
18—Gryphaeostrea vomer (Morton). ×2. Williamston, N.C., 110–20 feet, ANSP 16780. (p. 29)
19—Ostrea thirsae Gabb, ×2. Bladen Springs, Ala., 1000–8 feet, Ala. G.S. (p. 30)
20—Nucula ovula Lea. ×4, Savannah, Ga., 500–20 feet, ANSP 16779. (p. 29)
21—Spirulaea rotula (Morton). ×5, Lake Prince, Va., 270 feet, ANSP 16150. (p. 30)
22—S. mcglammerae (Gardner). ×4, Franklin, Va., 100–40 feet. ANSP 16010. (p. 30)
23—Callista neusensis Harris. ×2, New Bern, N.C., 80 feet, ANSP 16737. (p. 26)
24—Pecten delawarensis Richards and Harbison. ×3, Brandywine Lighthouse, N. J., 825 feet, ANSP 15936. (p. 30)
25—Cadulus turgidus Meyer. ×2, Bladen Springs, Ala., 1660–80 feet, Ala. G.S. (p. 30)



Richards, Fossils From Deep Wells

Richards, Fossils From Deep Wells

Tuscaloosa. The species was described from McNairy County, Tennessee. See discussion under *Hamulus protoonyx*, n. sp., which was found associated with this species in the well at Clayton, Alabama.

Corbula sp. Md. *18*, 1588–98.

Corbula spp. Md. *18*, 2257–67 (Raritan).

"Corbula" whitei Richards (pl. 14 figs. 3, 4). Md. 18, 1588–98.

Fulpia wicomicoensis (Richards) (pl. 14, figs. 1, 2). 18, 1588–98.

Exogyra woolmani Richards, n. sp. (pl. 14, figs. 7, 8, 11). Va. *4*, 780–5, *7*, 373–489; *13–2*, 265; S.C. *13*, 3115–3245.

Gryphaea vesicularis Lamarck (pl. 14, figs. 6, 19). Va. *4*, 780; *7*, 484–9 (Tuscaloosa).

Lucina parva Stephenson (pl. 14, figs. 12, 15). N.C. *27*, 76–84; *28*, 184–218 (Black Creek).

Ostrea knappi Stephenson (pl. 14, fig. 18). S.C. *11*, 2015 (Black Creek).

Ostrea peytoni Richards, n. sp. (pl. 14, figs. 9, 10). Ga. *27*, 3417–3447.

Pecten sealyi Richards, n. sp. (pl. 14, figs. 22, 23). Ga. *27*, 4158–4181.

Pecten sp. Ala. *4*, 4136 (Tuscaloosa).

Tellina? sp. Ala. 4, 4136 (Tuscaloosa).

Gastropoda

Avellana? sp. (pl. 14, fig. 21). Ala. *3*, 4210. One specimen, questionably referred to *Avellana* or *Neritina* was obtained from a well near Bladen Springs, Ala., and is presumably from the Tuscaloosa formation.

Cephalopoda

Belemnitella americana (Morton). N.J. *1*, 400 (Navesink); Md. *18*, x.

Annelida

Hamulus protoonyx Richards, n. sp. (pl. 14, fig. 16). Ala. 2, 2204–2235.

Hamulus howelli Richards, n. sp. (pl. 14, figs. 13, 17). N.C. *20*, 2247–2251; Ga. *27*, 4395–4425.

DESCRIPTIONS AND NOTES

Pleistocene

NUCULA MAJOR Richards

Plate 12, figures 1, 2

Nucula major Richards, 1944, Acad. Nat. Sci, Philadelphia Notulae Naturae, no. 134, pp. 8, 12. figs. 5, 6.

Shell large for the genus; solid, rounded. Anterior end rounded, posterior end broken. Outer surface covered with concentric lines; inner surface nacrous; six prominent teeth; beak and adjacent posterior teeth lacking in the type and unique specimen.

Type (incomplete) 21.5 mm.; estimated complete length 25.0 mm.; width 18.5 mm.

Mr. Richard McLean has recently called the writer's attention to the close relationship of these species with *N. shaleri* Dall (1894, 1898) from the Miocene of Marthas Vineyard, Massachusetts, although *N. shaleri* is smaller (15 mm. by 11 mm.).

Locality: Dredged from the Cape May Canal, Cape May County, N. J.

Age: Pleistocene (probably Wisconsin).

Type: ANSP 15938.

EXPLANATION OF PLATE 14

FIGS. *1, 2—Fulpia wicomicoensis* (Richards), ×4, Salisbury, Md., 1688–98 feet, ANSP 16712 (type). (p. 35)

3, 4—Corbula whitei Richards, ×4, Salisbury, Md., 1688–98 feet, ANSP 16713 (type). (p. 35)

5—Corbula crassiplica Gabb. ×5, Clayton, Ala., 1709–40, ANSP 16790. (p. 30)

6, 19—Gryphaea vesicularis Lamarck, ×2, *6*, Drivers, Va., 484–9 feet, ANSP 16789; *19*, ×2, Norfolk, Va., 755 feet, ASNP 16792. (p. 31)

7, 8—Exogyra woolmani Richards, n. sp., ×2, Norfolk, Va., 484–9 feet, ANSP 16775 (type). (p. 35)

9, 10—Ostrea peytoni Richards, n. sp., ×2, Albany, Ga., 3417–47 feet, ANSP 16794 (type). (p. 36)

11—Exogyra sp. ×1¾, Norfolk, Va., 755 feet, ANSP 16786. (p. 36)

12, 15—Lucina parva Stephenson, ×3½, Kinston, N. C., 60–70 feet, ANSP 16782. (p. 31)

13, 17—Hamulus howelli Richards, n. sp., *13*, ×4, Albany, Ga. 4395–4425 feet, ANSP 16785 16785 (type); ×4, Havelock, N.C., 2347–51, USNM. (p. 36)

14—Trochocyathus lunulitiformis (Conrad). ×3, Atlantic City, N.J., 950 feet, ANSP 16777. (p. 30)

16—Hamulus protoonyx Richards, n. sp., ×5, Clayton, Ala., 2204–34 feet, ANSP 16785 (type). (p. 37)

18—Ostrea knappi Stephenson, ×1, Charleston, S.C., 2015 feet, ANSP 16787. (p. 31)

20—Cardium penderense Stephenson, ×2, Wilmington, N.C., 105 feet, ANSP 16783. (p. 30)

21—Avellana? sp., ×2, Bladen Springs, Ala., 4228 feet, Ala. G. S. (p. 31)

22, 23—Pecten sealyi Richards, n. sp., ×2, Albany, Ga., 4158–81 feet, ANSP 16791 (type). (p. 36)

24—Siphonalia? johnsoni Richards, n. sp. ×2, Jacksons Mills, N.J., 50 feet, NJSM 10588 (type). p. 34)

Pliocene

CORBULA INAEQUALIS MANSFIELDI
Richards, n. subsp.
Plate 11, figures 27, 31

Corbula inaequalis (part) SAY, 1824, Acad. Nat. Sci. Philadelphia Jour., vol. 4, p. 153, pl. 13, fig. 2 (not 3).
C. inaequalis Say. MANSFIELD, 1939, U. S. Geol. Survey Prof. Paper 189-G, p. 224.

Shell moderately thick, convex, transversely ovate-trigonal; rough, unequal, coarse wrinkles; anterior margin with a very acute but short rostrum at its inferior termination. Base rounded and a little contracted near the anterior angle. Umbos not prominent.

The subspecies differs from the typical species by being larger and by having less distinct wrinkles.

Discussion.—*C. inaequalis* is an extremely variable species. Mansfield (Henbest, Lohman and Mansfield, 1939) p. 225, recorded large specimens from a well at Elizabeth City, N. C., between 50 and 55 feet. He dated these from the Croatan Pliocene and commented as follows:

> The specimens referred to this species are as a rule small in the Pliocene and larger in the Miocene. An exception is to be noted, however, in specimens from Station 8167, 3 miles southwest of Riverdale, N.C. Although I have correlated this locality with the Pliocene Croatan sand, the shells of *C. inaequalis* found there are larger than those commonly found in the Pliocene.

The specimens of *C. inaequalis* from the well at Harvey Neck, N. C., between 43 and 57 feet, are larger, especially in width, than usual representatives of these species and are therefore regarded as a distinct subspecies, *C. inaequalis mansfieldi*, that seems to be characteristic of the Croatan sand. They are similar to specimens in the United States National Museum which Mansfield found in the well at Elizabeth City, N. C.

The type of *C. inaequalis*, from Maryland, is 10.0 mm. long by 12.5 mm. wide; the type of *C. i. mansfieldi*, from Harvey Neck, is 13.0 by 17.0 mm.; two paratypes from Harvey Neck measure 11.0 by 15.5 mm. and 10.5 by 15.0 mm., respectively.

Locality: Harvey Neck, Perquimans County, N. C. (type 43–46 feet; also 43–57 feet); Elizabeth City, N. C. (50–55 feet).

Age: Pliocene (Croatan).

Type: ANSP 16765.

Named in honor of the late Dr. W. C. Mansfield, of the U. S. Geological Survey.

CITHNA PILSBRYI Richards, n. sp.
Plate 11, figure 17

Shell small, rather depressed, 3¼ whorls; base broad, convex. Umbilicus small but deep. Nuclear whorl smooth and glossy; other whorls increase rapidly. Whorls rounded without conspicuous carinae. Aperture large and approximately circular with a well-marked margin.

Height 0.5 mm.; diameter 1.5 mm.

The aperture is more circular than in *V. cingula* Verrill, which appears to be the most closely related species; also the whorls are more rounded and the carinae less distinct.

As far as is known, this genus has not been reported fossil from the United States, although it is known to be living in deep water off the East Coast. Other species are known from the Pliocene of Sicily and Calabria.

Locality: Edenton, Chowan County, N. C.; well 5, U. S. Marine Base; depth 34–46 feet.

Age: Pliocene (Croatan).

Holotype: ANSP 16769.

Named in honor of Dr. H. A. Pilsbry, of the Academy of Natural Sciences.

CONUS PARKERI Richards and
Harbison, n. sp.
Plate 11, figures 1–4

Shell of moderate size, rather solid and stout, with about eight or nine whorls in the adult; convex below the keel, which is sharp and without tubercles. Body-whorl sculpture consists of numerous threads and of five or more raised concentric lines at the anterior end of the canal. Sutures strongly impressed, aperture oblique, long and narrow and deeply notched at the upper end of the body whorl. Outer lip simple and fairly thick.

Type, length 30.0 mm.; width 16.0 mm.

Paratype, length 26.0 mm.; width 15.5 mm.

C. parkeri most resembles the Recent *C. mus* Hwass (=*C. citrinus* Gmelin), but differs from it in the absence of tubercules on the keel and in being stouter above the middle of the body whorl.

Locality: Well G.S. #11, 17 miles west of Boca Raton, Palm Beach County, Florida; depth 47–50 feet.

Age: Pliocene (Caloosahatchee).

Type: USNM 559928; Paratypes, USNM 559929; ANSP 16826.

Named in honor of Mr. G. G. Parker of the U. S. Geological Survey Ground Water Division at Miami, Florida, who collected the material and submitted it to the writer through Dr. John B. Reeside, Jr.

Miocene

ASTARTE MUNDORFFI Richards and Harbison, n. sp.
Plate 12, figures 15, 16

Shell small, subtrigonal, nearly equilateral and smooth. The beak is high and pointed and the lunule and escutcheon are narrow. The sculpture is composed of fine concentric striations, which become much more noticeable toward the beak. The pallial line is distinct and the adductor scars are moderately strong. The hinge is characteristic of the genus.

Length (type) 16.5 mm.; diameter 17.5 mm.

A. mundorffi is related to *A. exaltata* Conrad but is characterized by a less impressed lunule, the lack of a crenulated margin, and the absence of a sharp extra tooth.

Locality: Bogue, Cartaret County, N. C.; depth 130 feet.

Age: Miocene (Yorktown).

Type: ANSP 16741.

Named in honor of M. J. Mondorff, of the U. S. Geological Survey, who is working in coöperation with the North Carolina Geological Survey on the ground water of North Carolina, and who is responsible for calling the attention of the author to the collection of fossils containing this and other North Carolina species recorded in this paper.

GLYCYMERIS BOGUENSIS Richards and Harbison, n. sp.
Plate 12, figures 13, 17

Shell small, subcircular in outline and almost equilateral. Beaks small, pointed, and slightly off-center. Hinge plate with about seven teeth on each side of the beak becoming more oblique away from the center, and without chevrons below the beaks. Radial ribs are fine, equidistant, about 38 in number becoming indistinct toward both margins. Radial ribs crossed by many fine concentric lines. Umbos are flattened, and there is a slight keel at the left of the margin. Adductor scars are oval in outline and prominent, the posterior one bounded by an inconspicuous radiating ridge. Pallial line strong. Inner margin finely crenulated, the crenulations being smaller near the hinge line.

Diameter 18.0 mm.; length 16.0 mm.

Paratype diameter 12.0 mm.; length 11.5 mm.

G. boguensus is related to *G. pennacea* Lamarck from the Miocene of South Carolina. This new species has a flatter umbo, coarser radial sculpture, and is less convex. A very definite characteristic is the absence of the chevrons on the hinge line.

Locality: Bogue, Cartaret County, N. C. depth 130 feet.

Age: Miocene (Yorktown).

Type: ANSP 16740.

CORBULA CHIPOLANA CAROLINA Richards, n. var.
Plate 11, figures 34, 35

Our specimen resembles the typical *C. chipolana* Dall, except that the muscle scar is somewhat larger, and the sculpture is slightly coarser, verging toward that of *C. waltonensis* Gardner. In *C. chipolana* the sculpture is usually carried across the rostral keel, which is not the case in this specimen. *C. chipolana* is abundant in the Chipola formation of Florida, and this is apparently the first record north of that state.

Diameter 4.0 mm.; length 5.0 mm.

Locality: Bogue, Cartaret County, N. C.; depth 130 feet.

Age: Miocene (Yorktown).

Type: ANSP 16750.

PHACOIDES TRISULCATA ALBEMARLENSIS Richards, n. subsp.
Plate 11, figure 26

One slightly broken valve resembles *P. trisulcata* (Conrad) except for its greater size. It may be a very senile example of the typical, but in view of the fact that it is twice the size of normal, it seems desirable to designate it as a distinct subspecies.

Length 13.0 mm.; width 14.5 mm.

Locality: Edenton, Chowan County, N. C.; depth 51–45 feet.

Age: Miocene (Yorktown) or Pliocene (Croatan).

Type: ANSP 16772.

Named for Albemarle Sound on which Edenton is located.

ACTEOCINA CEDERSTROMI Richards, n. sp.
Plate 11, figure 9

Shell small, smooth, subcylindrical, somewhat rounded at top and bottom. Nucleus conspicuously elevated; three whorls, closely coiled. Top of shell almost flat; whorls separated by channeled sutures; aperture narrow, widening toward base. Inner surface of shell thinly glazed. Columella with single fold, which merges into the thickened labial margin near the base.

Length 4.2 mm.; width 2.0 mm.

Related to *A. incisula* Dall, but with more conspicuous nucleus, more conspicuous columellar fold, and somewhat smoother surface.

Locality: Bacon's Castle, Surry County, Va.; depth 115 feet.

Age: Miocene (Yorktown).

Type: ANSP 16771

Named for D. J. Cederstrom, of the U. S. Geological Survey in Charlottesville, Va., who is working in coöperation with the Virginia Geological Survey, and who has assisted the writer in the present project.

ACTEOCINA CHOWANENSIS Richards, n. sp.
Plate 11, figure 10

Shell small, short, smooth, subcylindrical. Nucleus elevated and fairly conspicuous. Three whorls closely coiled; top of shell slightly rounded; conspicuous keel at base of third whorl. Aperture narrow; outer margin slightly irregular, with a constriction about two-thirds from the top of the shell to the bottom. Aperture conspicuously larger at the base. Columellar fold faint.

Length 3.8 mm.; width 1.6 mm.

Differs from *A. cederstromi* by its smaller size, more rounded top and angular outline. More closely related to *A. persimilis* Dall, but with less conspicuous columellar fold and relatively shorter length.

Locality: Edenton, Chowan County, N. C.; well 3, U. S. Marine Base; depth 46–58 feet.

Age: Miocene (Yorktown).

Type: ANSP 16754.

MITRELLA EDENSIS Richards and Harbison, n. sp.
Plate 15, figure 6

Shell small, slender, and thin; sutures lineal, slightly impressed, spiral sculpture slight on basal portion of body whorl; aperture ovate, about one third the length of the body whorl; outer lip thickened, without denticulations on the columella.

Length 3.5 mm.; diameter 1.5 mm.

M. edensis resembles *M. lunata* Say but differs from it in having one less whorl, in being more slender, and in having fewer impressed revolving lines near the anterior end of the canal.

Locality: Edenton, Chowan County, N. C. Well 5; depth 72 feet.

Age: Miocene (Yorktown).

Type: ANSP 16761.

Eocene

PECTEN SEABEENSIS Richards, n. sp.
Plate 12, figure 18

Shell moderately small, slightly convex; ribs well developed from beak to margin. Approximately 37 ribs; sulcations especially prominent near the left margin. Ribs usually bipartite, occasionally tripartite. Moderately faint concentric laminae, which form minute scales. Ears unequal, similar to *P.* (*Clamys*) *decemnarius* Conrad.

Length 13.4 mm.; width 11.5 mm.

Close to *P.* (*Clamys*) *decemnarius* Conrad, but with fewer and slightly closer spaced ribs.

Locality: Camp Peary (Seabee Base), York County, Va.; depth 380 feet.

Age: Eocene (Pamunkey).

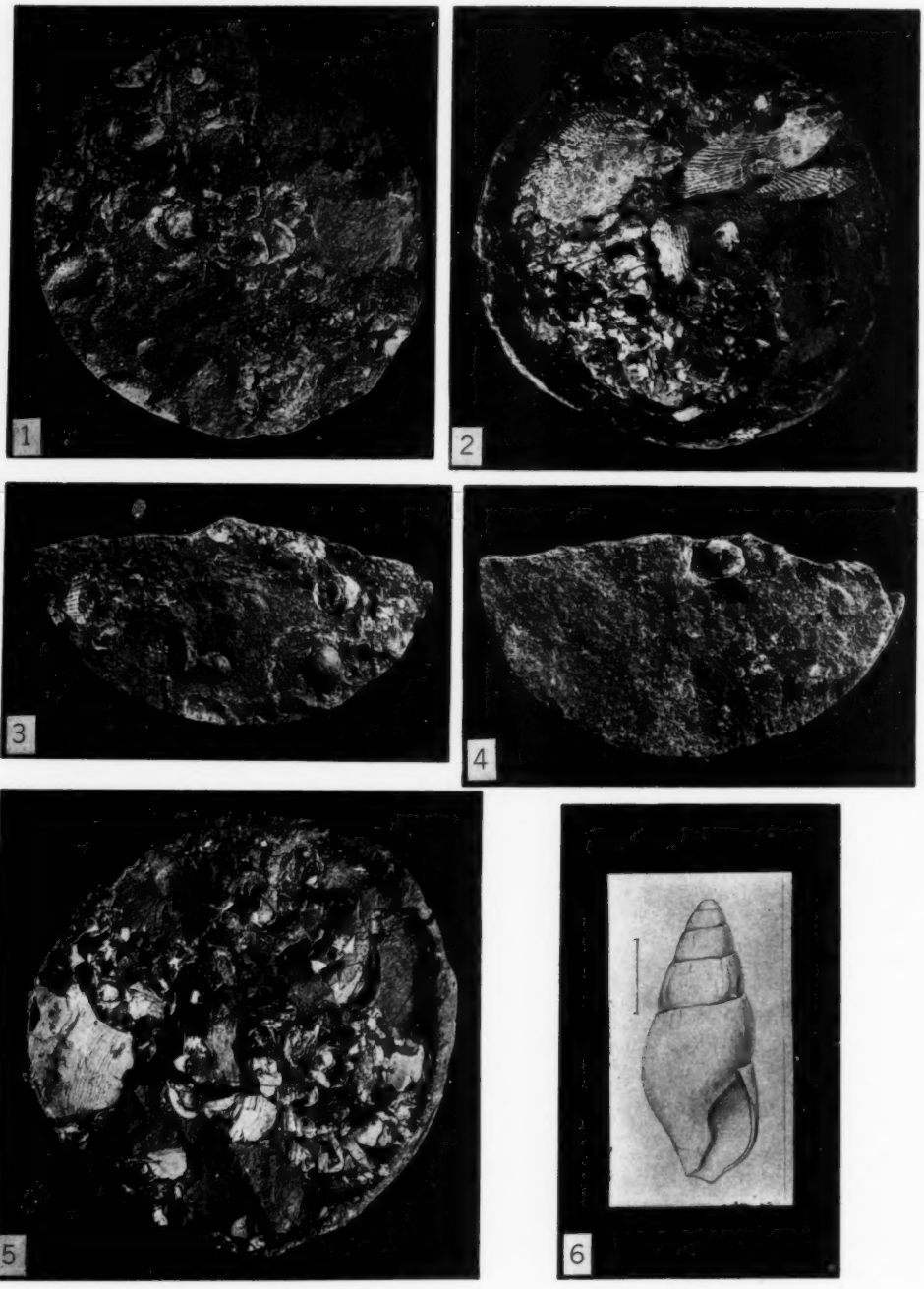
Type: ANSP 16781.

SIPHONALIA? JOHNSONI Richards, n. sp.
Plate 14, figure 24

Shell short, fusiform. Lower portion of canal broken away; four whorls; apex flattened. Although very poorly preserved it is possible to make out definite nodes on the whorls beginning near the suture; faint traces of revolving ribs.

So little of the original shell is left that it is impossible to definitely assign this specimen to a genus. It probably was a highly ornamented form and is questionably assigned to *Siphonalia*.

Length 21.0 mm.; diameter 13.5 mm.



Richards, Fossils From Deep Wells

UNIV. OF

Locality: Jackson's Mills, Ocean County, N. J.; depth 50 feet.

Age: Ecoene (Shark River-Manasquan).

Type: New Jersey State Museum 10588.

Named for Meredith E. Johnson, State Geologist of New Jersey, who called the attention of the writer to material from this well.

Upper Cretaceous

BRACHYDONTES SALISBURYENSIS (Richards)
Plate 15, figure 2

Mytilus? salisburyensis RICHARDS, 1945, Am. Assoc. Petroleum Geologists Bull., vol. 29, p. 1202.

Shell of moderate size, subcircular; umbos not shown but apparently central. Finely striated, with ribs equidistant from each other; no trace of concentric ribs. Very nacreous.

Length 18.0 mm.; width 7.0 mm.

Locality: Ohio Oil Company Hammond Well, 6 miles east of Salisbury, Wicomico County, Maryland; depth 1688–98 feet. Common but poorly preserved.

Age: Upper Cretaceous (Matawan or Raritan).

Type: ANSP 16711.

CORBULA (CARYOCORBULA) WHITEI
Richards
Plate 14, figures 3, 4

Corbula? whitei RICHARDS, 1945, Am. Assoc. Petroleum Geologists Bull., vol. 29, p. 1202.

Left valve with shell smooth, subtriangular; beak incurved; prominent groove below the beak. Resembles *C. crassiplica* Gabb, but has slightly higher beak and is more equilateral.

Length 4.0 mm.; width 5.0 mm.

Locality: Ohio Oil Company Hammond Well, 6 miles east of Salisbury, Wicomico County, Maryland; depth 1588–98 feet. Also Socony-Vacuum well near Berlin, Worcester County, Md.; depth 2970–80.

Type: ANSP 16713.

Named for Stanley B. White of The Ohio Oil Company who provided the material from the Salisbury well.

FULPIA WICOMICOENSIS (Richards)
Plate 14, figures 1, 2

Corbicula wicomicoensis RICHARDS, 1945, Am. Assoc. Petroleum Geologists Bull., vol. 29, p. 1202.

Fulpia wicomicoensis (Richards). STEPHENSON, 1946, Jour. Paleontology, vol. 20, p. 70.

The specimens originally referred to this species were few and poorly preserved. It was recognized that they belonged to the family Corbiculidae, but the new genus *Fulpia* had not been named.

Length 5.5 mm.; width 4.5 mm. (broken).

Locality: Ohio Oil Company Hammond well, 6 miles east of Salisbury, Wicomico County, Maryland; depth 1588-98 feet.

Age: Originally referred to the Matawan. Because of its relationship with *Fulpia pinguis* Stephenson from the Lewisville unit of Texas, Stephenson tentatively correlates the deposit with the Raritan.

Type: ANSP 16712.

EXOGYRA WOOLMANI Richards, n. sp.
Plate 14, figures 7, 8, 11

Shell small, rather thin, variable in shape. Lower valve convex. Beak slender and coiled to the left. Faint concentric growth lines.

Very similar and possibly identical with *E. columella* Meek from the Eagle Ford formation of Texas, also New Mexico. The East Coast specimens do not show the radiating costae mentioned by Meek in *E. columella*. Also the average size is smaller than *E. columella*.

Type: length 11.0 mm.; width 10.0 mm.; paratype length 20.0 mm.; width 14.5 mm. Both from Norfolk, Va.

Discussion: Woolman (1899, p. 98) in discussing the artesian well at Norfolk, Va., mentioned some specimens of *Exogyra* between 715 and 755. He noted a

small *Exogyra* precisely similar to *E. costata* but having a smooth surface and showing only faint

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EXPLANATION OF PLATE 15

FIGS. *1*—*Corbula* sp. and *Tellina* sp. ×2, Scotch Lumber Co., Ala., 4136 feet, Ala. G. S. (p. 31)
2—*Brachydontes salisburyensis* (Richards). ×1½, Salisbury, Md., 1688–98 feet, ANSP 16711 (type). (p. 35)
3, 4—*Corbula* sp. ×2, Scotch Lumber Co., Ala., 4136 feet, Ala. G. S. (p. 35)
5—*Corbula* sp. ×1½, Salisbury, Md., 1688–98 feet, ANSP 16800. (p. 35)
6—*Mitrella edenensis* Richards and Harbison, n. sp., ×10, Edenton, N.C., ANSP 16761 (type). (p. 34)

costations. They vary in length from ¼ to ⅜ inches.

This was apparently the first recognition of this species on the Atlantic Coast.

One flattened upper valve with distinct growth lines was found in the Norfolk well (755 feet) associated with *E. woolmani*, and is probably of the same species (pl. 14, fig. 11).

Localities: Norfolk, Va., 755 feet, type and 9 others; Drivers, Va., 484–9 feet, 1 specimen (16776); Franklin, Va., 265 feet, 2 specimens.

Several casts, probably of this species were noted in cores from the well at Parris Island, S. C., between 3115 and 3245. The samples are at the Georgia Geological Survey in Atlanta, Ga.

Age Upper Cretaceous (Tuscaloosa).

Type: ANSP 16775 (Norfolk); paratypes: 16776; 16786 (Norfolk).

Named for Lewis Woolman, who collected the samples from the Norfolk well and who recognized the species as distinct.

Ostrea peytoni Richards, n. sp.
Plate 14, figures 9, 10

Shell ovate, of moderate size, quite thin at ventral margin and slightly thicker near the beak. Beak small and slightly off-center. Outer surface moderately rough with indications of concentric growth lines; no radial lines.

The shells are young and appear to be related to *O. oleana* Stephenson from the Cretaceous of deep wells in Mississippi, but are much more elongate.

Length 19.0 mm.; width 6.0 mm.

Locality: Sealy well, 7 miles west of Albany, Dougherty County, Ga. Depth 3417–47 feet.

Age: Upper Cretaceous (Tuscaloosa).

Type: ANSP 16794.

Named for Captain Garland Peyton. Director of the Department of Mines, Mining and Geology of the State of Georgia, who supplied the writer with the samples from this well.

Pecten sealyi Richards, n. sp.
Plate 14, figures 22, 23

Shell rounded, flat, 21 ribs, well rounded and prominent. Interspaces smooth and about one and one-half times the width of the ribs. Ribs show signs of beads near the umbo. Concentric lines faint, but slightly more conspicuous near the umbo. Ears slightly broken, but approximately equal.

Not like any species described from the East Coast Cretaceous. This, however, is not entirely surprising since very few species, and none of *Pecten*, are described from the Tuscaloosa formation. On the other hand, it is possible that the shells are younger and fell from above. In addition to the type, six broken shells apparently of the same species were taken in the sample.

Length 20.0 mm.; width 26.0 mm.

Locality: Sealy well, 7 miles west of Albany, Dougherty County, Ga.

Age: Upper Cretaceous (Tuscaloosa).

Type: ANSP 16791.

Hamulus howelli Richards, n. sp.
Plate 14, figures 13, 17

Known only from the holotype and one other specimen somewhat questionably referred to this species.

The holotype tube is small for the genus, but appears to be complete. It is 7 mm. long and 2 mm. in diameter at its widest part. It is gently and evenly curved throughout its entire length. Its six ribs are sharp, not rounded. In form the tube is similar to that of one of the more gently curved tubes of *H. falcatus* (Conrad), as figured by Howell (1943, pl. 19, figs. 17, 20, 22). However, the tube of *H. howelli* is much smaller than the average tube of *H. falcatus*, which is about 30 mm. long.

Locality and Age: The holotype is from J. R. Sealy's Reynolds Brothers Lumber Company well No. 1, 7 miles west of Albany Dougherty County, Georgia. Depth 4395–4425; referred to the marine phase of the Tuscaloosa, which in this well is unusually thick. See Richards, 1945, pp. 925–6. Another specimen, questionably referred to this species, is from the Great Lakes Drilling Company well near Havelock, Craven County, North Carolina, between the depths of 2347–2351, also from the Tuscaloosa formation.

Discussion: The tube of *H. howelli* looks like a miniature tube of the New Jersey species *H. falcatus*. However, this cannot be, for it is too small in all its dimensions for a

tube of that species; it is probably an ancestor of *H. falcatus.*

The specimen from Havelock, N. C., is smaller and more curved than the holotype of *H. howelli* but resembles it in other respects. Some of the tubes of *H. falcatus* are much more curved in their youthful stages than others, and such may also have been true of *H. howelli.* The Havelock tube is only 4 mm. long and 1.5 mm. in diameter, although it appears to be complete.

Although the specimens from Albany, Ga., and Havelock, N. C., are both referred to the Tuscaloosa formation, it is not certain that they are of exactly the same age. The Havelock specimen may therefore represent a stratigraphically different subspecies. However, its true relationship can be finally determined only after more tubes have been procured from the Tuscaloosa formation elsewhere so that a more complete series can be studied.

Type: ANSP 16784. (Albany, Ga.)

Figured specimen: USNM (Havelock, N. C.).

Named in honor of Dr. B. F. Howell, of The Academy of Natural Sciences and Princeton University.

HAMULUS PROTOONYX Richards, n. sp.
Plate 14, figure 16

Known only from the holotype tube, which lacks the smaller end. The larger, anterior portion of the tube, which probably represents somewhat more than half of the tube, is 4 mm. long and 2 mm. in diameter.

Tube similar in form to that of *H. onyx* Morton, but much smaller and possibly less curved. The portion of the holotype that is preserved is straight, as is the anterior part of the tube of *H. onyx;* when more complete specimens of *H. protoonyx* are found, their smaller tapered portion will probably be found to be curved. The average tube of *H. onyx* is some 15 mm. long, while that of *H. protoonyx* could not be more than 8 mm.

The six rounded ribs on the outer surface of the tube of *H. protoonyx* are similar in form to those on the outer surface of *H. onyx,* except that they are smaller. As far as can be determined from the holotype, the inner wall of the tube is smooth, as is the case with *H. onyx.*

Locality: From H. A. Stebinger's Robertson No. 1 well, near Clayton, Barbour County, Alabama; depth 2204–35 feet.

Discussion: Although the tube of *H. protoonyx* looks like a miniature tube of *H. onyx,* it cannot be the tube of a young individual of *H. onyx,* for the smaller (youthful) portion of the tube of that species is considerably larger in all its dimensions than the tube of *H. protoonyx;* also the ribs on the youthful portion of the tube of *H. onyx* are not rounded, as they are in *H. protoonyx,* but are sharp.

H. protoonyx is probably a small ancestor of *H. onyx,* for it is found in beds that are somewhat older than the oldest ones from which *H. onyx* has been reported. Howell (1943, p. 150–2) reports *H. onyx* from the Tombigbee member of the Eutaw formation, while *H. protoonyx* comes from the lower part of the Eutaw or the Tuscaloosa.

Age: Upper Cretaceous (Eutaw or Tuscaloosa).

Type: ANSP 16785.

REFERENCES

DALL, W. H., 1894, Notes on Miocene and Pliocene of Gay Head, Marthas Vineyard, Mass., and on land phosphate of the Ashley River district, South Carolina: Am. Jour. Sci., ser. 3, vol. 48, p. 298.

——, 1898, Contributions to the Tertiary fauna of Florida: Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 575, pl. 40, fig. 6.

HENBEST, L. G., LOHMAN, K. E. and MANSFIELD, W. C., 1939, Foraminifera, diatoms and mollusks from test wells near Elizabeth City, North Carolina: U.S. Geol. Survey Prof. Paper 189-G.

HOWELL, B. F., 1943, *Hamulus, "Falcula,"* and other Cretaceous Tubicola of New Jersey: Acad. Nat. Sci. Philadelphia Proc., vol. 95, pp. 139–166.

RICHARDS, H. G., 1944, Notes on the geology and paleontology of the Cape May Canal, New Jersey: Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 134, 12 pp., 8 figs.

——, 1945, Subsurface stratigraphy of Atlantic Coastal Plain between New Jersey and Georgia: Am. Assoc. Petroleum Geologists Bull; vol. 29, pp. 885–955.

—— and HARBISON, ANNE, 1942, Miocene invertebrate fauna of New Jersey: Acad. Nat. Sci. Philadelphia Proc., vol. 94, pp. 167–250.

—— and HARBISON, ANNE, 1944, Well boring at Brandywine Lighthouse in Delaware Bay, part 1; geology and macrofossils: Acad. Nat. Sci. Philadelphia Notulae Naturae, no. 132.

WOOLMAN, LEWIS, 1900, Artesian wells: New Jersey State Geologist Ann. Rept. for 1899, pp. 55–139.

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FOSSIL PLANTS AND HUMAN FOOTPRINTS IN NICARAGUA

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AMONG the stored collections of fossil plants in the United States National Museum I recently found three fragments bearing only the label "Dr. Earl Flint, Nicaragua. Bocano group." The significance of these specimens was not apparent until, on investigating the identity of Flint, I learned that in the late 1870's and early 1880's he was an archaeological collector located at Rivas, Nicaragua; and that, in this interval, he reported the discovery of human footprints in consolidated volcanic mud at two localities—one at El Cauce, in the western outskirts of Managua, on the south shore of Lake Managua, uncovered during quarrying operations for building stone; and the other in similar matrix near San Rafael, on the coast, 40 miles southwest of Managua. Specimens of these footprints can be seen at both the Peabody Museum of Harvard University and the United States National Museum (plate 1, fig. 3); and others have been illustrated by Brinton (1887, opp. p. 437) and Roberts (1945, pl. 10, figs. 1, 2).

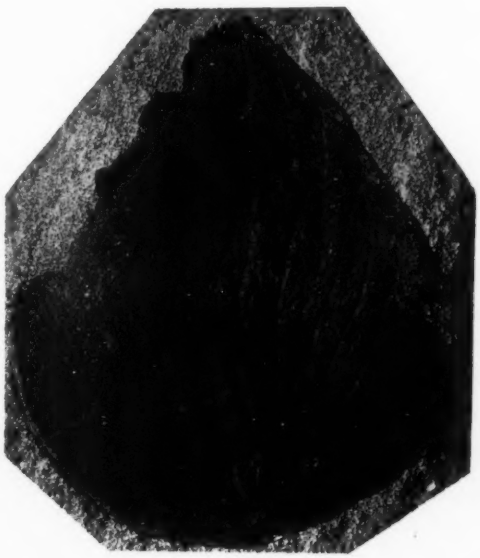
In the same stratum as the human footprints are tracks of deer, otter, birds, and lizards, but no artifacts have yet been recovered from this level. Exploitation of the footprint-bearing horizon at El Cauce had been carried on for several years under the direction of F. B. Richardson of the Carnegie Institution of Washington until work was interrupted by the war in 1941.

Flint's description of the geological setting for the footprint occurrences and the adjacent areas is somewhat amateurish and incoherent, but Brinton (1887, p. 440) managed to get from him a fair vertical section of 21 feet at the El Cauce quarry. This section becomes more intelligible from the recent observations made by Howel Williams and quoted by Richardson (1941, p. 300); and from the photographs published by Roberts (1945, pl. 10, figs. 1, 2). The footprint-bearing bed is directly underlain by yellow sand. Brinton (1887, p. 441) erroneously stated that this sand contained the little fresh-water shells which were tentatively referred to *Pyrgula*. Flint (1890, p. 32) vigorously chided Brinton for this misrepresentation, saying there was no connection between the sand and the shells. This is confirmed by a letter from Flint on December 22, 1886, to the Smithsonian Institution, in which he specifically says that the shells came from the shore of a small lake six miles northwest of Managua. Below this sand are hundreds of feet of ash. Overlying the footprint bed is a sequence of thin layers of black cinders intercalated between thick layers of the same material as the footprint bed. These thick strata are composed of volcanic mud or tuff, said to be like that which inundated Herculaneum, Italy, and that probably hardened within a relatively short time after eruption.

From the stratum immediately overlying the footprints Flint made a considerable collection of fossil leaves which was sent to the Peabody Museum (Putnam, 1884, p. 355, 356) in the hope that it might yield a clue to the age of the footprints. Six or seven years previously, however, Flint (1885, p. 156) also found fossil leaves in what he called the "Bocano group" in the

EXPLANATION OF PLATE 16

FIG. *1*—*Prioria tufficola* Brown, n. sp. From San Rafael, Nicaragua, ×1. (p. 39)
2—*Prioria copaifera* Grisebach. Pod of a living species from Panama, introduced for comparison, ×1. (p. 39)
3—Human footprint in tuff from El Cauce, near Managua, Nicaragua. Specimen on exhibit at the United States National Museum ×0.43. (p. 38)



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Brown, Fossil Plants and Human Footprints

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vicinity of San Rafael near the coast and sent these, together with mollusks from the immediately underlying stratum, to the National Museum. In the absence of further data, my first problem, therefore, was that of determining whether the specimens I had rediscovered were those sent by Flint from San Rafael or were collateral with those from El Cauce and sent to the Peabody Museum. I hoped that a comparison of matrixes would solve this problem. The authorities of Peabody Museum, however, inform me that, although the Flint collection received by them was referred to Leo Lesquereux for identification (Putnam, 1884, p. 356), they can now find neither an identification by Lesquereux nor a subsequent record of the collection.

The presumption is strong that the three plant fragments now in the National Museum were those collected by Flint near San Rafael. Unfortunately, Flint, in his garbled eagerness to maintain great antiquity for the footprints at both San Rafael and El Cauce, and in his uninhibited use of the terms "cataclysm," "glaciation," "primitive," and "upheaval" in describing the attendant geologic conditions (Flint, 1885, p. 156; Brinton, 1887, p. 443), conveys a confusing picture of the situation and is particularly obscure in stating the relations between the leaf-bearing, mollusk-bearing, and footprint-bearing strata at San Rafael. The only established fact seems to be that the leaves overlie the mollusks. The stratigraphic position of the San Rafael footprint-bearing tuff, therefore, remains problematical. Obviously, this region needs restudy by a competent geologist, so that the phenomena described by Flint may be fitted into a chronological sequence of events.

The mollusks that underlie the leaves at San Rafael are unusually large. According to Woodring (1928, p. 89) the collection contains, among others, species of *Malea*, *Ostrea*, *Chione*, and *Harvella*, indicating Pliocene or Quaternary age.

The matrix of the leaf-bearing stratum has a greenish-gray cast and is a compact, fine-grained tuffaceous sandstone composed of rounded quartz grains, decomposed feldspar, and minor amounts of other minerals. Only one of the plant fragments from this bed can be identified. Its features are so characteristic that it can be recognized with certainty as the impression of a pod of the legume genus *Prioria*.

PRIORIA TUFFICOLA Brown, n. sp.
Plate 16, figure 1

Pod slightly asymmetric, oblong-ovate in outline, with broadly rounded base and blunt apex, 7.5 cm. long and 6 cm. wide. Surface rugose with irregularly curved and roughly parallel major veins that run from the basal peduncular scar to the apex. Minor branches from these veins anastomose in a streaming network. The large amount of carbon left in the impression suggests that the original pod was thick and tough.

The fossil pod strongly resembles that of *Prioria copaifera* Grisebach, a leguminous tree, locally called cativo, that may generally be found near the coast from Nicaragua to Colombia and Jamaica. This tree, sometimes 30 m. high, has compound leaves with two pairs of leaflets that are asymmetric, lanceolate-elliptic, and 10–16 cm. long. At maturity the tough, flattened pods contain one seed. The pods and seeds are said to be edible and are favored by peccaries.

Inasmuch as the fossil pod appears to be almost, if not exactly like that of the living species, I hesitate, except for the purpose of reference, to give it a different specific name. For the same reason, and also because this is the first reported fossil occurrence of the genus, I can say little about its age implications, except that it appears to be a late rather than an early form. From my experience with fossil fruits and seeds, however, I should add that in many instances they are extremely conservative and display few if any differences from their living equivalents, even though millions of years may have meanwhile elapsed. For example, fruits of *Ailanthus lesquereuxi* Cockerell, from the middle Eocene Green River formation of Wyoming can be matched very closely by samples from the living *Ailanthus altissima* Swingle. Nevertheless, the association of *A. lesquereuxi* with many species, whose living equivalents, if any, are not associated with *A. altissima* today, stamps that association or combination with the aspect of its age. Thus, it seems evident that if plants are to be used in helping to date the human footprints in Nicaragua better col-

lections tied to definite horizons in authentic stratigraphic sections must be forthcoming; and a thorough census of the present vegetation of the region must be available for comparison with such fossils.

REFERENCES

BRINTON, D. G., 1887, On an ancient human footprint from Nicaragua: Am. Philos. Soc. Proc., vol. 24, pp. 437–444.

FLINT, EARL, 1884, Human footprints in Nicaragua: Am. Antiquarian, vol. 6, p. 112–114; 1885, idem, vol. 7, pp. 156–158.

——, 1890, Letter in Science, vol. 15, pp. 30–32.

PUTNAM, F. W., 1884, Report of the curator: Peabody Museum of Am. Archaeology and Ethnology, Ann. Repts. 16 and 17, pp. 355–356.

RICHARDSON, F. B., 1941, Report on Nicaragua: Carnegie Inst. Washington Yearbook no. 40 for 1940–1941, pp. 300–302.

ROBERTS, F. H. H., JR., 1945, The New World Paleo-Indian: Smithsonian Inst. Ann. Rept. for 1944, pp. 403–433.

WOODRING, W. P., 1928, Miocene mollusks from Bowden, Jamaica, Part 2: Carnegie Inst. Washington Pub. 385, p. 89.

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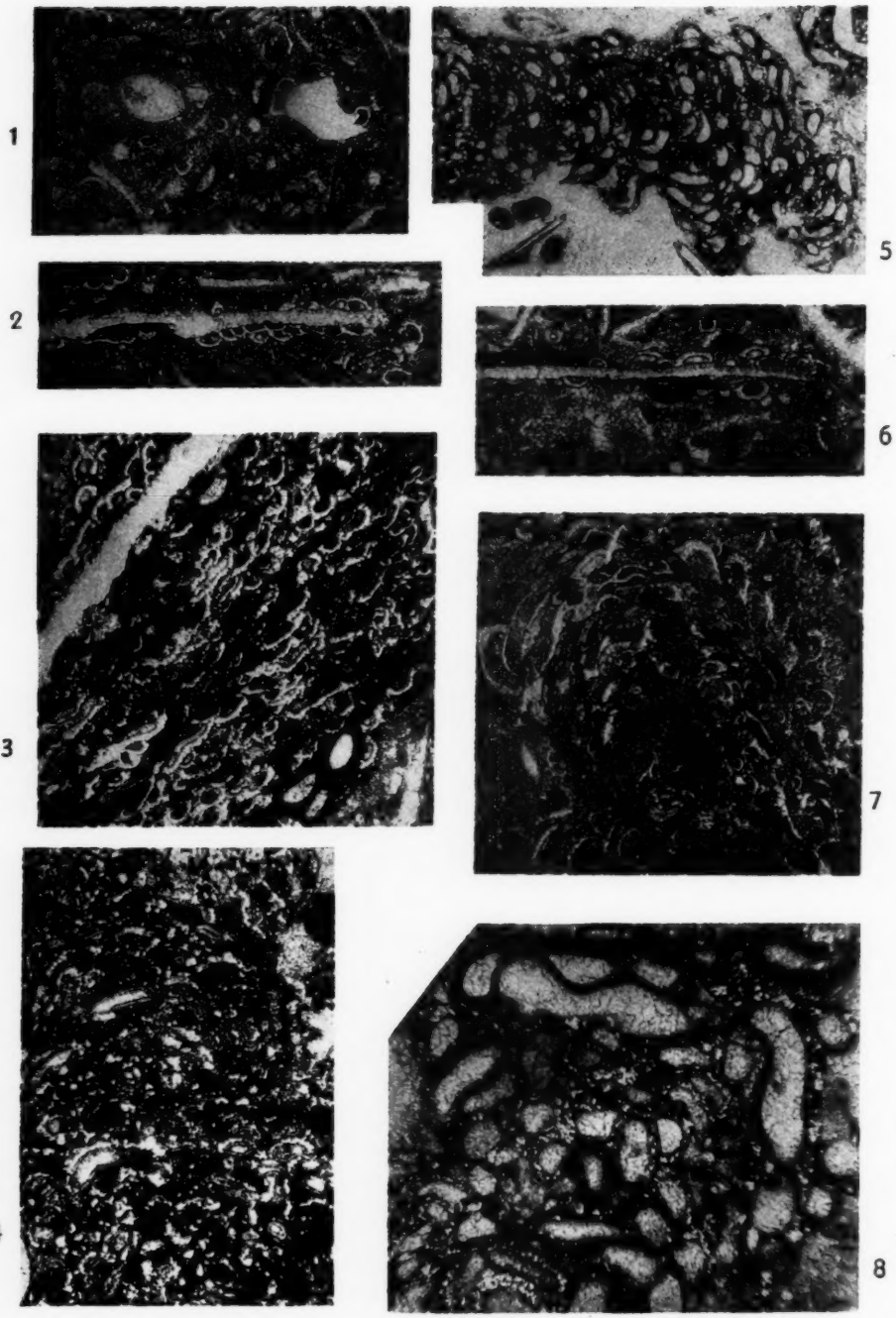

Johnson, *Nubecularia*

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NUBECULARIA FROM THE PENNSYLVANIAN AND PERMIAN OF KANSAS

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ABSTRACT—Foraminifera belonging to the genus *Nubecularia* occur in Kansas in rocks ranging in age from early Mid-Pennsylvanian (Altamont limestone) to near the close of early Permian (Fort Riley limestone). Locally they are abundant. They occur singly and in large colonies. Many are intimately associated with calcareous algae. These occurrences are described and illustrated in this paper.

RECOGNITION OF THE GENUS

THE foraminiferal genus *Nubecularia* was named by Defrance in 1825 on the basis of specimens from the Tertiary of France. It is represented by several living species that occur in warm shallow waters, particularly in the East Indies and the West Indies, and it has a long fossil record. The genus is well known from the Tertiary of Europe, especially the Miocene. Jones and Parker (1860) have described a species from the Jurassic of England, and representatives of *Nubecularia* have been described from the Cretaceous of England. Chapman (1909) has described a form from the Triassic of New South Wales. An occurrence of the genus in the Permo-Carboniferous of Tasmania, which is questioned by some recent students, has been reported by Howchin (1894). Abundant material containing the genus was found by Johnson (1938) in Upper Pennsylvanian beds (Magdalena limestone) of New Mexico in 1937. Confirmation of the generic determination has been given by Miss Juliette Pfender of the Laboratory of Geology at the Sorbonne, who kindly studied some of this material.

A recent study of limestones from the Pennsylvanian and Permian of Kansas shows that representatives of *Nubecularia* occur rather commonly at several horizons. These are reported and partly illustrated in this paper.

DESCRIPTION OF NUBECULARIA

Galloway (1933, p. 116) gives the following description of *Nubecularia:*

Test attached, with no lower wall, planispiral chambers few, closely appressed: wall calcareous, apparently imperforate, much thickened by the addition of sand grains on the outside; aperture at base of last chamber, simple. Length up to 6 mm. Warm shallow water. Carboniferous (?Howchin), Triassic (?), Eocene to Recent.

Cushman (1940, p. 183) subdivided *Nubecularia* into several genera and gave the following revised description for the genus:

Test typically coiled, at least in the young, free or usually attached, with an oval proloculum and coiled tubular chamber, followed in the adult by irregular chambers varying more or less with the attached surface. Jurassic to Recent, perhaps earlier.

Howchin (1894, p. 345) described Permo-

EXPLANATION OF PLATE 17

FIG. *1*—*Nubecularia*. A few individuals, ×35. Upper part of Burr limestone.
2—*Nubecularia* on a shell fragment, ×35. Upper part of Burr limestone.
3—*Nubecularia* and algae. Thick coating on a shell, ×35. Upper Burr limestone. The algae form black masses filling chambers and perforating the walls of the Foraminifera. Note perforation and alteration of the walls of the Foraminifera.
4—*Nubecularia* and algae, ×35. Funsten limestone.
5—A plumose colony of *Nubecularia* and algae, ×25. Funsten limestone.
6—*Nubecularia* on a shell fragment, ×35. Upper part of Burr limestone.
7—*Nubecularia* and algal threads, ×30. Top of Iola limestone.
8—An enlarged detail of a colony of *Nubecularia* and algae from same slide as *5*, ×55. Shows the destructive work of algae in disintegrating and altering the walls of the Foraminifera. The white grains are the calcite debris.

TABLE 1.—SPECIMENS OF NUBECULARIA FROM PENNSYLVANIAN AND PERMIAN ROCKS OF KANSAS
(Dimensions in millimeters)

	Formation	Average chamber		Thickness of wall		Average size of colony	Occurrence	Associated plants (Algae)	Associated Animals
		Length	Height	Top	Bottom				
LOWER PERMIAN	Fort Riley limestone	0.2250	0.1350	0.0210	0.0162	3.50× 1.10	*Osagia* coatings around organic fragments.	*Girvanella* sp. *G.* aff. *moorei.* Fine threads 0.0027–0.0036.	Fusulinids, small foraminifers. Echinoids, crinoid fragments, bryozoans.
	Funston limestone	0.380	0.090	0.0135	0.0054	2.65× 0.88	Plumose colonies with fine algal threads.	*Girvanella dia.* 0.0310. Threads 0.0027–0.0036.	Small foraminifers, ostracods, shell fragments.
	Beattie-Morrill	Very variable Max. 0.270	0.2250	0.0730	0.0117	2.42× 0.57	*Osagia* coatings & irregular colonies.	*Girvanella dia.* 0.04 & 0.053. Threads 0.0027–0.0036.	Small foraminifers, bryozoan & echinoderm fragments.
	Neva limestone	0.070	0.0135	0.0135	0.0056	1.32× 0.55	*Osagia* colonies.	*Girvanella dia.* 0.0176. Threads 0.0066–0.0040.	Small foraminifers, gastropods, fragments shells, bryozoa, echinoids.
	Burr limestone	Very variable 0.270 0.1580	0.0670 0.0710	Very variable 0.0360 0.0320	0.0180 0.0140	20.0× 1.1 *Map*	Long slender *Osagia.* Also separate colonies and individuals.	*Girvanella dia.* 0.045. Threads 0.0018–0.0027.	Small foraminifers & shell fragments.
	Roca shale	0.2030	0.090	0.0198	0.0120	2.01× 0.70	Long slender colonies of *Osagia* type.	*Girvanella dia.* 0.0176. Threads 0.0036.	Fragments shells, bryozoa, echinoids, crinoids.
	Foraker limestone	0.150	0.0520	0.0190	0.010	2.20× 1.21	Rounded colonies *Osagia* type.	Threads 0.0036.	Fragments shells, echinoderms, bryozoa.

TABLE 1.—(*Continued*)

	Formation	Average chamber		Thickness of wall		Average size of colony	Occurrence	Associated plants (Algae)	Associated animals
		Length	Height	Top	Bottom				
PENNSYLVANIAN	Grand Haven limestone	0.1210	0.0506	0.0330	0.0070	0.58×0.51	Small rounded *Osagia* colonies.	*Girvanella dia.* 0.015–0.002; threads 0.004.	Fragments bryozoa, echinoid, & gastropods.
	Elmont limestone	0.1180	0.0480	0.0220	0.0090	3.30×1.50	Long colonies *Osagia* type.	Threads 0.0036	Fragments shells, echinoids, & gastropods, small foraminifers.
	Reading limestone	0.1760	0.0840	0.0220	0.0110	3.20×0.70	*Osagia*-type colonies.	Branching threads 0.008.	Small foraminifers, fragments echinoderms & brachiopods.
	Severy shale	0.220	0.050	0.0130	0.0090	4.84×3.96	*Osagia*-type colony.	Threads 0.0027–0.0018.	Fragments brachiopods, bryozoa, echinoiderms.
	Deer Creek limestone	0.2750	0.0550	0.0220	0.0066	2.42×0.77	*Osagia*-type colony.	Threads 0.003–0.005.	Fragments shells, bryozoa & echinoderms & small foraminifers.
	Iola limestone	0.2860	0.1580	0.0390	0.0132	3.08×2.60	Plumose colonies and *Osagia*	Branching threads 0.0045–0.0054.	Small foraminifers. Fragments bryozoa, shells, crinoids.
	Hertha limestone	0.330	0.1230	0.0480	0.0110	5.70×1.50	Colonies *Osagia* type.	0.070 and 0.003 threads.	Bryozoa and echinoderms.

Pennsylvanian material from Tasmania under the name *Nubecularia lucifuga* var. *stephensi* as follows:

Type description.—Habit of growth closely resembling the type. Initial chamber, globular. Subsequent chambers, elongated and slightly inflated. Chambers arranged, either on a spiral-line plan, in rectilinear order, or in irregular acervaline masses. Walls of the test, thin, uniform in thickness, and sharply defined in outline. Septal divisions marked on exterior surface by sunken lines.

Type level.—Near base of Permo-Carboniferous series. Marine limestone.

Type locality.—Outcrop on the right bank of the River Piper, not very far from Lilydale, north-eastern district of Tasmania, Australia.

OCCURRENCES IN KANSAS

Numerous examples of *Nubecularia* have been observed in connection with a study of fossil algae in late Paleozoic rocks of Kansas. They range in age from early Mid-Pennsylvanian (Altamont limestone) to near the close of early Permian (Fort Riley limestone). Table 1 shows the characteristic dimensions and association of these fossils.

It is interesting to note that generally, though not invariably, the specimens of *Nubecularia* are associated with algae, and the same is true of many previously reported occurrences. Gillet and Derville (1931, p. 734) and Derville (1936, p. 487) have described several such associations.

In the upper Pennsylvanian and lower Permian of Kansas numerous small pellet-like fossils are found which are composed of an intimate intergrowth of algae of several types and *Nubecularia*. Such fossils, which have a fairly uniform size and shape, are abundant and widespread. Twenhofel (1919) gave them the name *Osagia*. They are described at length by the author in another paper (Johnson, 1946).

Nubecularia occurs both singly (pl. 17, figs. 1, 2, 6) and in colonies (pl. 17, figs. 3–5). The individuals commonly start with a rounded chamber and to this a number of elongated chambers are added in a straight or sinuous row (pl. 17, figs. 1, 2, 6). The wall, which is thin or absent at the base, thicker along the sides, and thickest at the top, seems to have been composed of very fine grained calcite. The colonies are composed of numerous individuals, which grow superimposed one upon the other, forming irregular coatings around fragments of fossils or developing into long plumy masses that may attain a length of several centimeters (pl. 17, figs. 4, 5).

Possibly more than one species of *Nubecularia* is represented in the Kansas Pennsylvanian and Permian material, but the irregular and variable form of all described species makes it difficult to differentiate them.

NATURE OF THE ASSOCIATION WITH ALGAE

Two types of algae occur with *Nubecularia* in the Kansas limestones: *Girvanella*, which has sinuous tubular filaments showing well-defined walls; and unnamed types having very fine threadlike forms. *Girvanella* commonly occurs as a coating on *Nubecularia* or entwined among specimens, which suggests a symbiotic association. The fine threadlike types coat and penetrate the walls of the foraminifers and fill many of the chambers. Where they occur in abundance, the walls seem to have been thoroughly perforated and partially dissolved, and in some instances reduced to separated fragments of calcite (pl. 17, fig. 8). These algae may have been parasitic, but they certainly were destructive. In the larger compound *Nubecularia* colonies, usually the lower, older part of the colony shows the Foraminifera to have been filled and partly or completely destroyed by these fine algal filaments, while around the margins unaltered or only slightly altered Foraminifera may occur (pl. 17, figs. 4, 8). The same association and results have also been observed in the basal portions of some of the large plumose *Nubecularia* colonies (pl. 17, fig. 5).

REFERENCES

CHAPMAN, F., 1909, On some microzoa from the Wianamatta shales, New South Wales: New South Wales Geol. Surv., Dept. Mines, Records, vol. 8, pt. 4, art. 27, p. 336.

CUSHMAN, J. A., 1940, Foraminifera: their classification and economic use. 535 pp., 58 pls., Harvard University Press.

DEFRANCE, M. J. L., 1825, Mineralogie et geologie: Dictionaire des sciences naturelles., t. 35, p. 210. F. G. Levrault, Paris.

DERVILLE, H., 1935, Observations et reflexions sur le genre *Nubecularia:* Soc. géol. France Bull., sér. 5, t. 5, pp. 621–628, pl. 29.

——, 1936, Manière d'être des algues dans les calcaires à nubeculaires: Soc. géol. France Bull., sér. 5, t. 6, pp. 487–494, pl. 34.

GALLOWAY, J. J., 1933, A manual of Foraminifera. 483 pp., 42 pls., Principia Press, Bloomington, Indiana.

GILLET, S., and DERVILLE, H., 1931, Nouveau gisement d'un récif à *Nubecularia* à Cricov, prés de Chisinau (Bessarabie): Soc. géol. France Bull. sér. 5, t. 1, pp. 721–738, 4 pls.

HOWCHIN, W., 1894, On the occurrence of Foraminifera in the Permo-Carboniferous rocks of Tasmania: Australasian Assoc. Adv. Sci. Rept. 5th Meeting at Adelaide South Australia, 1893. Sec. C., vol. 5, no. 8, p. 345.

RECEIVED MARCH 6, 1946.

JOHNSON, J. HARLAN, 1938, *Nubecularia* and *Girvanella* from the Pennsylvanian near La Luz, New Mexco (abstract): Geol. Soc. America Bull., vol. 49, no. 12, pt. 2, p. 1889.

——, 1946, Lime-secreting algae from the Pennsylvanian and Permian of Kansas: Geol. Soc. America Bull., vol. 57, no. 12, pp. 1087–1120, 10 pls., 5 figs.

JONES, T. R., and PARKER, W. K., 1860, On some fossil Foraminifera from Chellaston near Derby: Geol. Soc. London Quart. Jour., vol. 16, p. 455.

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PERMOPORA KEENAE, A NEW LATE PERMIAN ALGA FROM TEXAS

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ABSTRACT—*Permopora keenae*, a new genus and species from the Childress dolomite of Northern Texas, is related to the living *Neomeris stipitata* and closely resembles some Triassic and Jurassic Dasycladaceae of central and southeastern Europe. Fragments of the sterile stage of the plant are cylindrical, with lateral branchlets arranged in whorls internally paired by stem annulations. The fertile stage, apparently referable to the same plant, contains casts of apparent aplanosporangia in the angles of junction of sterile branchlets.

It is suggested that the method used in the study of fusulines be applied to the study of the abundant Permian Dasycladaceae. This method consists of the liberation of individuals from the rock matrix, the preparation of oriented sections, and the standardization of measurement of various structural details.

INTRODUCTION

DR. MYRA KEEN, curator of Paleontology at Stanford University, cordially offered for my examination a peculiar fossil donated to Stanford University by H. T. Beckwith in 1914, and labeled by Dr. J. W. Beede provisionally as "Bryozoan? sp., probably new genus and species." The material proved of considerable interest and is here described as *Permopora keenae*, a new genus and species of the family Dasycladaceae or Siphoneae Verticillatae, of the class of green algae.

Because the collection contained material from three localities in close proximity to each other, and all samples looked so much alike as to suggest origin from the same rock formation, I sent some photographs of the fossil and a sample of the fossiliferous rock to Dr. Robert Roth, who has done considerable work on the Permian of northern Texas, and asked him if he could possibly locate them with a greater precision in the local geological section than Beckwith's 1914 designation of "Double Mountain beds." Roth generously supplied the desired information and also an exact legal description of the three localities, for which I express my sincere appreciation. He states that he has known about this fossil's existence for several years, and that samples containing it have been brought into his office by a number of people who thought they might be large fusulinids. The samples from the three localities, according to Roth, undoubtedly came from the Childress dolomite, in which he has seen large numbers of them. He says that the Childress dolomite occurs on an average of 10 feet above the base of the Custer and that it is stratigraphically considerably older than the Dozier lens, from which Beede (1907) and Newell *et al.* (1940) described numerous invertebrates. This latter remark was made by Roth because I mentioned to him that I recognize some of the Dozier mollusks in the samples with *Permopora*.

Thanks to the courtesy of Mr. Ronald K. De Ford of Argo Oil Company I subsequently visited and collected from localities of *Mizzia* and other Dasycladaceae in the Carlsbad limestone southwest of Carlsbad. These fossils were recently described and illustrated by J. Harlan Johnson (1942), who is continuing his studies on them. There are no fossils referable to *Permopora* among them.

I am indebted to Dr. J. Brookes Knight for the photographs of figures 2 and 11 of plate 18; the rest of the negatives were photographed by me.

The following is the account of the stratigraphic position, biologic nature, and paleontologic significance of *Permopora*.

LOCATION, STRATIGRAPHY AND ASSOCIATED FAUNA

The rock containing *Permopora* is very light gray to nearly white porous dolomitic limestone, which dissolves nearly completely

in cold hydrochloric acid. It is full of fragmentary internal casts of *Permopora* and casts of immature gastropods and pelecypods. The samples were collected from the Childress dolomite member, which lies 5 to 21 feet above the base of the Custer group, which is the highest fossiliferous Permian of north-central Texas and southwestern Oklahoma. The columnar section in Hall County, Texas, measured and published by Roth (1937, p. 454) indicates the position of the Childress dolomite about 217 or 218 feet below the "Dozier Mounds dolomite" or simply the Dozier dolomite. From the type outcrops of the Dozier at Dozier Post Office in Collingsworth County were collected the "White Horse" invertebrates described by Beede (1907), and later collected again at this and other localities, and redescribed by Newell, Knight, Brill and Moore (1940).

The mollusks associated with *Permopora* are generally much like those from the Dozier dolomite, but their exact identification in the small fragments of Childress dolomite studied is difficult because they are represented by only young individuals. It seems that immature *Dozierella gouldii* Beede is present and there is certainly an immature *Murchisonia* cf. *M. gouldii* Beede, which identifications are supported by Dr. Keen's subsequent information that there were several specimens of mature *Dozierella gouldii* and *Murchisonia gouldii* in the same lot with the alga (letter of Dec. 24, 1945). The following list of localities of the specimens deposited by Beede at Stanford University were supplied by Roth.

1. About 200 yards northeast of No. 1 G. R. Cooper well, NW ¼ sec. 325, blk. H, W. and NW Survey, about 2½ miles north, 60° east of Childress, Childress County, Texas. From here come the best fossils. Stanford University Paleo. Type Coll. 7904.

2. Northwest corner Buckle L Ranch, NW corner sec. 655, blk. H. W. and NW Survey (6 mi. south, 4 mi. west of Childress), Cottle County, Texas. Stanford Univ. Paleo. Type Coll. 7905.

3. Southwest corner Buckle L Ranch, SW corner sec. 661, blk. H, W. and NW Survey (13 mi. south, 4 mi. west of Childress), Cottle County, Texas. Stanford Univ. Paleo. Type Coll. 7906.

GROWTH STAGES AND CALCIFICATION OF A LIVING ALGA

In order to understand the biologic meaning and mutual relationship between various fragments of apparently a single species of a radially symmetrical alga in the Childress dolomite, I searched through the literature on living Dasycladaceae for the description of a species that would possess features resembling those observed in the fossil fragments investigated. I found only one paper in which a living species and its growth stages are described and illustrated in sufficient detail to allow a point-by-point comparison with the fossil here described. This is the investigation by Church (1895) of what he believed to be *Neomeris dumetosa* Lamouroux, but which was subsequently proved by Howe (1909) to represent a different (new) species, *Neomeris stipitata* Howe. Because the investigation by Church is still unsurpassed by any subsequently published ones on the same or related living species or related fossil forms, I review here the essential data and illustrations from his essay, with emphasis on the particular features in the living form that are recognizable on fossil *Permopora*.

Neomeris stipitata is a small tropical calcareous alga with adult thallus reaching 35–40 mm. in height and with the largest diameter across the cortical zone 2 to 2½ mm. The specimens that Church examined came from "smooth shallow water, attached to mud or piles" near Singapore, each individual looking "very much like a little green sausage." The main axis is flexible and bears a delicately calcified upper portion. Another species of the same genus in the same area is *N. kelleri* Cramer, a smaller but densely calcified species growing between coral blocks exposed by the tides.

N. stipitata in its ontogenetic development passes through five stages of growth, from simpler to more complex, which usually can be recognized in mature individuals, and which were all studied by Church in detail. Of the five stages of growth the third and fourth, which are adult vegetative stages, and possibly the fifth, which is its reproductive stage, seem generally comparable with the growth stages recognizable on fragments of *Permopora*. These stages of *Neomeris* will be described in some detail.

The stages III and IV of *Neomeris* are illustrated by figure 3 (after Church). This portion looks like a miniature ear of corn, the axis of the stem like a cob, and the verticillated sterile basal segments of the lateral appendages or branchlets like the kernels of corn. New verticils of branches are being gradually developed at the apex, while the earliest, lowermost appendages of stages I and II are deciduous and fall off, leaving small circular scars on the stem (figs. 1, 2). Though the whorled short appendages of the stages I and II are slender and do not touch each other, the basal appendages of stages III and IV are, on the contrary, short, thick, and so tightly packed, that they form a continuous cortical zone, on the outer side of which the individual basal segments assume polygonal, usually hexagonal outlines (fig. 3). Calcification of these basal segments aids in their coherence and helps their preservation before and after the death of the plant; to them apparently correspond the similar, external, prevailingly hexagonal, verticillate segments of the fossil *Permopora*. In *Neomeris* the basal or cortical segments bear slender digits or segments of the second order, which fall off readily; they leave small scars of attachment, which are easily obliterated.

In *Neomeris stipitata* the growth stage III is succeeded by a somewhat similar growth stage IV (fig. 3). As Church explains, in stage IV the segments of the first order become thinner and shorter, and each bifurcates in the plane of a whorl into two thick segments of the second order, which are closely packed and continue to build the cortical zone flush with that built by the basal or first order segments of stage III. This is the interpretation by Church, but it seems more nearly correct to say that the basal segments of stage III, when reaching stage IV, differentiate into three parts or subsegments: a small and slender proximal and two distal subsegments. The fine drawing by Church (fig. 3) will bear out this statement, as it shows that the distal sub-

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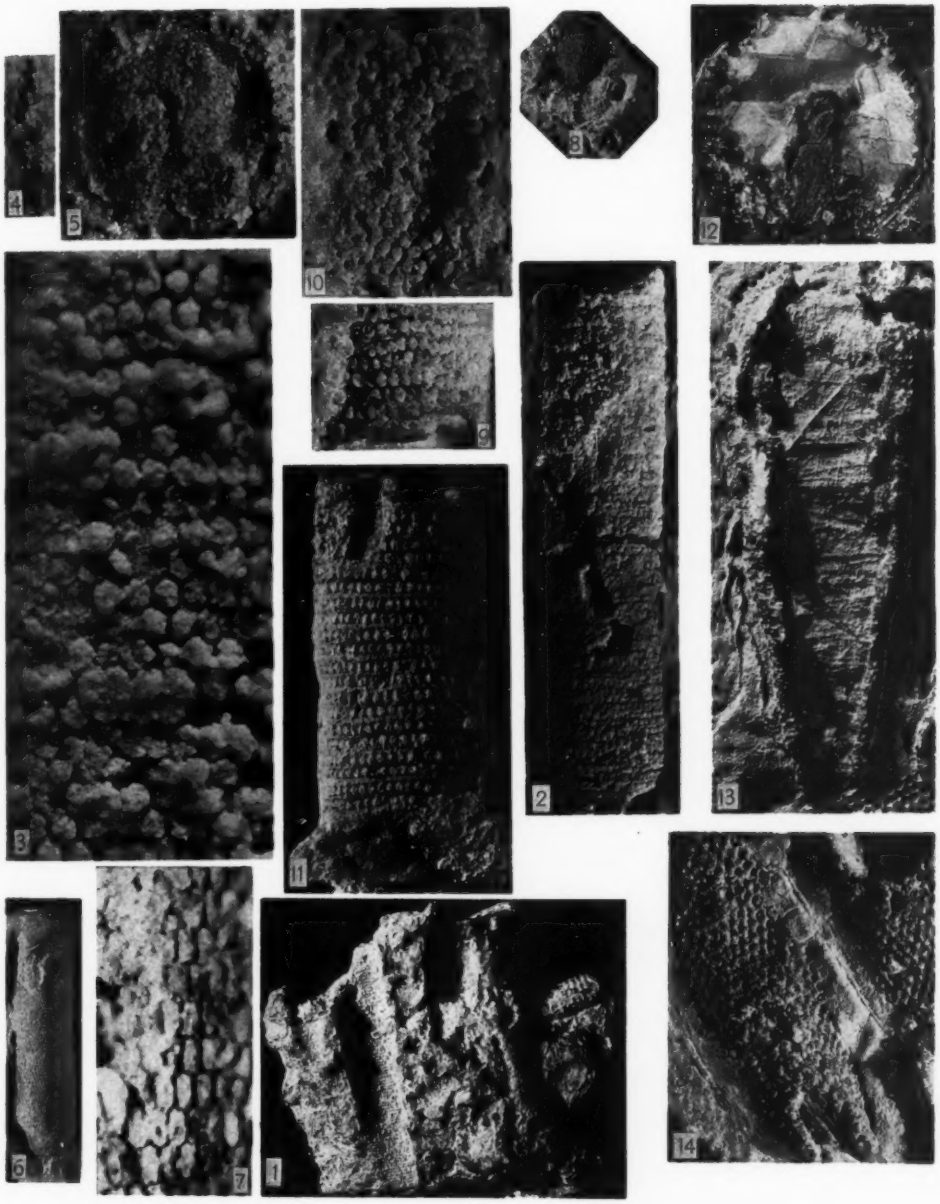
EXPLANATION OF PLATE 18

FIGS. *1–11—Permopora keenae* Elias, n. gen., n. sp. *1*, Three large cylindrical casts, from left to right nos. 6, 7 and 2 (holotype), embedded in white cavernous dolomite; Stanford Univ. coll. no. 7904, ×2. *2*, Specimen 7, ×20. *3*, Detail of negative (concave) specimen 6 with about equilateral facets characteristic of the distal or upper part of the sterile stage, ×20. *4*, Longitudinal break along the calcified jacket of cortical zone, its outer surface to the left, to show its thickness and profile of annulations (between first and second, and third and fourth branchlets from above); specimen 7, Stanford Univ. coll. 7904, ×10. *5*, Transverse break across specimen 3, to show thickness of calcified jacket of cortical zone with numerous equal branchlets, each terminating in a facet; Stanford Univ. coll. no. 7904, ×10. *6*, Plaster cast from negative (concave) specimen 5, to show how approximately the calcified jacket looked from outside before being embedded in the sediment; Stanford Univ. coll. no. 7904 ×2. *7*, Detail of negative (concave) specimen 11, with elongately hexagonal, and occasionally elongately rectangular facets, characteristic of proximal or lower part of the sterile stage; Stanford Univ. coll. no. 7904, ×20. *8*, Fertile (left, specimen 4) and sterile (right, specimen 3) stages, possibly of same individual plant, broken at surface of junction and moved apart for a distance of 5 mm., without losing parallel orientation; specimen broken from the right side of that illustrated in fig. *1;* Stanford Univ. coll. 7904, ×2. *9*, Detail of positive sterile cast no. 3, shown in fig. *8* (right), which is possibly a terminus of sterile stage, to which the base of fruiting stage was attached, as indicated by location of fig. *10* in probably correct position in relation to fig. *9;* ×10. *10*, Detail of negative fertile specimen 4, shown in fig. *8* (left); to show regularity of basal row of sterile facets, probably at the point of attachment to sterile stage shown in fig. *9*, below; and the checkerboard to irregular arrangement of larger facets upwards; spherical casts in the angles of junction of the facets are believed to be aplanosporangia; compare with same in *Neomeris stipitata* in text figures 4 and 5; ×10. *11*, Positive sterile specimen 2 (holotype) to show alternate annulations and grooves between the whorls of circular "stumps" of lateral branchlets; the paired character of the whorls is most typical of the genus; the specimen is from the right edge of Stanford Univ. Coll. no. 7904, illustrated in fig. *8;* ×20. (p. 53)

12–14—Mastopora (*Nidulites*) *pyriformis* (Bassler). Ordovician, Virginia. From a topotype in the U. S. National Museum. *12*, Weathered cross section of uppermost part, ×2. *13*, Complete individual, weathered to the central axis, ×2. *14*, Outer view of lower portion of partially weathered individual, for comparison with fertile stage of *Permopora* (figs. *8*, left, and *10*), ×2. (p. 55)



Elias, Permian Algae

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segments of stage IV occur at the same distance from the stem as the outer portions of the undifferentiated segments of stage III, and they all build together a continuous common cortex. When observing the number and size of cortical segments in the verticils referred by Church to stage IV, it seems clear that they actually are made of both subsegments of stage IV and the simpler basal segments of stage III, mixed together. Therefore, these verticils should be classified not as strictly stage IV, but rather as mixed III–IV stage. After four verticils of this mixed stage are developed, two verticils of stage III follow, and after these the verticils of stage IV (or rather mixed III–IV) are reestablished. According to Howe (1909), who investigated the same species of *Neomeris* and named it *N. stipitata*, "the arrangement of the facets is commonly very irregular, rather more so than it might be inferred from Church's figures 17, 21, and 24" (his fig. 17 is here reproduced as text fig. 3).

The fifth and last growth stage in *Neomeris stipitata* is the adult reproductive stage. It differs from stage IV essentially only by the addition to the latter of reproductive organs in the form of spherical structures; aplanosporangia attached by short stalks upon the distal end of "first order segments" or subsegments, in the angle between the cortical segments of stage IV. The change to the fruiting stage is also manifested by the elongation of the vegetative subsegments of stage IV, which results in the expansion and somewhat bulbous appearance of the whole distal part of the plant.

The number of whorls and of their cortical segments in *Neomeris stipitata* is as follows: in stage I from 40 to 80 whorls, with the number of basal segments in each gradually increasing from 12 to 18; in stage II from 28 to 46 whorls, the average being 37; in stage III in average 43 whorls and as many as 100, with the number of basal segments from 16 to 22; in stage IV from 200 to 300 whorls, with 22 to 30 or 32 basal segments in each; the aplanosporangia of stage V are developed at least in 60 of the highest whorls of stage IV.

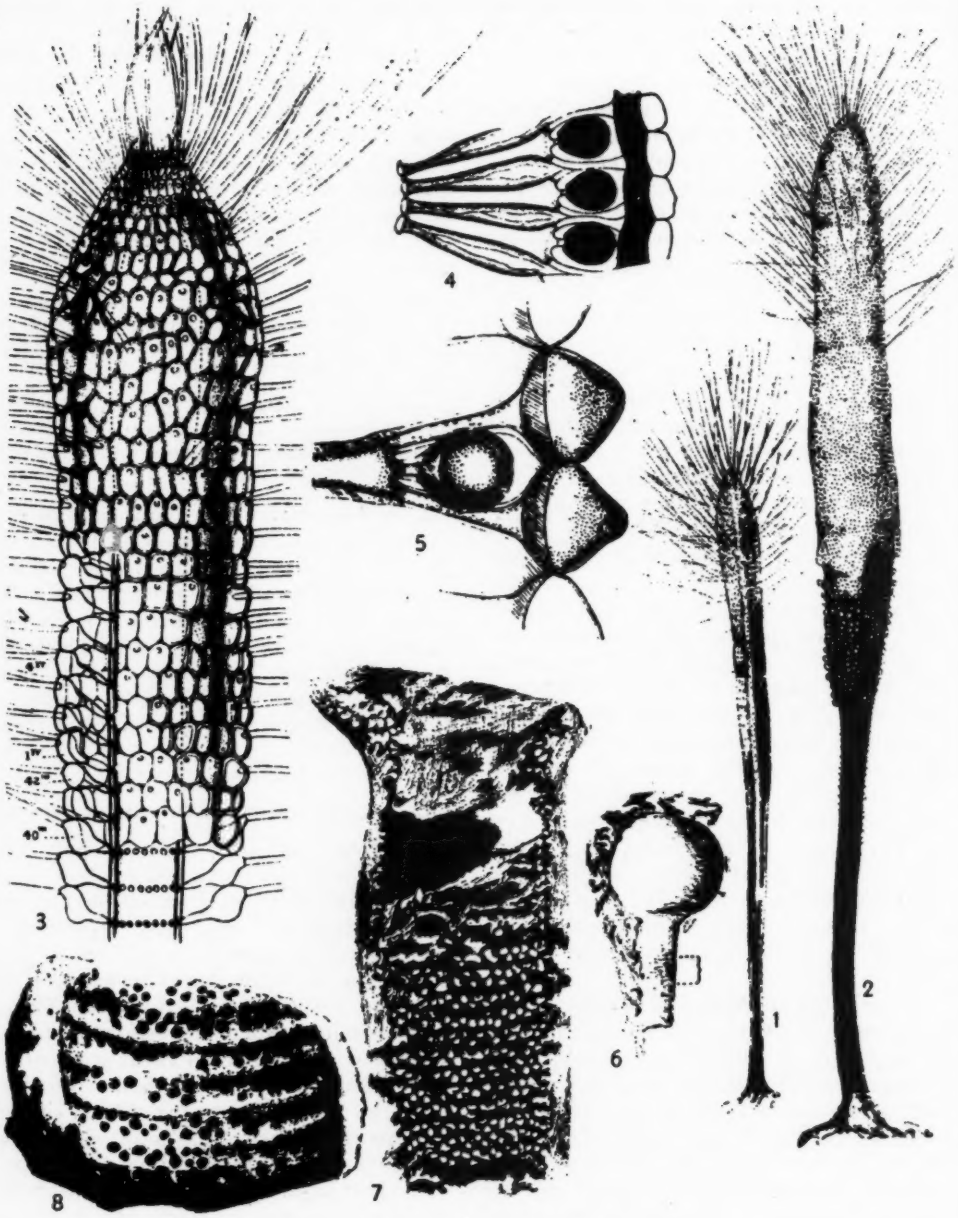
Calcification of *Neomeris stipitata* is unequally developed and its localization in *Neomeris* provides an apparent explanation why only some parts of the whole original plant *Permopora* have been preserved in fossilization. Church observes that the apex of *Neomeris* is not calcified, "the first trace of deposit being found at about the tenth node (whorl) from the growing point" (Church, 1895, p. 590). The thickest incrustation is found in the cortical segments, the maximum calcareous deposit forming a layer beneath their expanded ends and thus makes

> a continuous calcareous jacket, perforated by the slender non-calcified pedicel-portions of the cortical segments: a small deposit is laid down on the basal segments; the main axis, growing-point, surface of the thallus, and filamentous portions of the appendages do not incrust; but the aplanosporangia are densely coated to a distance more than half-way down their pedicels. (Church, 1895, p. 592).

It is this continuous cylindrical and perforated "jacket" that is preserved when the plant dies and thus may be buried and fossilized; subsequently the perforations in the jacket may become mineralized (for instance, filled with calcite), after which the jacket itself may be dissolved, as this apparently happened with the remains of *Permopora* in one sample of the Childress dolomite.

BIOLOGICAL INTERPRETATION OF PERMOPORA

The fragments of *Permopora* seem to compare well with the mature vegetative stages III and IV of *Neomeris stipitata*, and one isolated fragment seemingly represents a reproductive stage not unlike that in *Neomeris*. The chief differences between *Permopora* and *Neomeris* are (1) a whorl in *Permopora* contains a much larger number of basal segments, (2) individual basal segments in *Permopora* have a much wider proximal part and so produce much larger circular scars on the surface of the main axis or stem; (3) calcification of the proximal part of these very short basal segments and of the surface of the stem is more complete and uniform in *Permopora;* (4) the change in branchlets of *Permopora*, which may be somewhat compared with the change from stage III to stage IV in *Neomeris*, is however of different nature, and is manifested only by a general gradual modification of the shape of the



FIGS. *1–8*—For explanation see opposite page.

facets from elongate hexagonal and occasionally elongate rectangular in the proximal or lower part of the stem to more nearly equilateral hexagonal in the distal or higher part of the stem. This change is therefore generally the reverse of that in the facets of *N. stipitata*, those in the latter being narrower in stage IV than in stage III (see text fig. 3).

The single collected fragment illustrated on plate 18, figures 8 and 10 is interpreted as a fruiting stage, in all probability of *Permopora keenae* because it contains small subspherical or pyriform molds in the angles between the polygonal segments, suggestive of the occurrence of aplanosporangia in the club-shaped distal part of *Neomeris stipitata*. The shape of this fossil specimen suggests a subspherical cortical "jacket" which is not unlike the spherical and subspherical distal parts of many fossil Dasycladaceae; the apparent nonpreservation of the basal parts of the cortical segments in this fragment seems due to its being the apical part of a thallus. Compare the above-described *Neomeris stipitata* in which there is no calcification of the pedicel portions of the cortical segments and of the axis.

In all sterile fragments of *Permopora* the outer surface of the cortical zone apparently has not been preserved, as the cortical segments blend or fuse distad with the rock matrix. This peculiarity apparently indicates that the outermost part of the cortical segments did not calcify, just as the corresponding part in the cortical segments of *Neomeris stipitata* (text figs. 4, 5) does not calcify beyond its calcified "jacket." The fossil is apparently an inner cast of such a "jacket," produced by mineral filling of the perforations in the "jacket."

TAXONOMIC DESCRIPTION

CHLOROPHYCEAE (GREEN ALGAE)
Family DASYCLADACEAE
Genus PERMOPORA Elias, n. gen.

Stem hollow, cylindrical, not bifurcating, covered with verticillate lateral appendages or branchlets, the short basal segments of which are preserved and form by lateral contact a cylindrical cortical zone; the basal segments of the neighboring whorls usually alternate, so that on the outer surface of the cortical zone their facets are hexagonal, seldom modified to tetragonal, and apparently correlative of sterile stages III and IV of *Neomeris stipitata;* the whorls are internally paired by development on the stem of flangelike annulations after every other whorl.

A probable reproductive stage, suggestive of stage V of *Neomeris*, is subspherical or

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EXPLANATION OF FIGURES

All figures seven-eights of original size

FIGS. *1–5*—Living *Neomeris stipitata* Howe (= *N. dumetosa* Church, not Lamouraux). *1*, Young plant in stage IV, just commencing calcification; ×4.5±. *2*, Adult plant in reproductive stage; at top are filamentous upper portions of branchlets or appendages, which are deciduous and do not calcify; calcareous cortical region or "jacket" descends about three-fourths way down the swelled distal part, and as it disintegrates below, the densely calcified aplanosporangia are exposed; farther down are remnants of basal segments of sterile branchlets. *3*, Upper portion of plant passing from stage III to stage IV, with brief recurrence of stage III above four whorls of stage IV, as indicated by general change of facets from wider to narrower; in the lower three whorls branchlets are broken off in front to show circular scars upon the stem. *4*, Transverse section of adult plant in reproductive stage at about middle of its calcified portion. Number of branchlets in a whorl is 30–32; intensity of shading indicates degree of calcification; ×45±. *5*, Part of transverse section of same stage as *4;* diagonal shading indicates calcification in the mucilaginous cortical regions; ×90±. All figures from Church, 1895, pl. 22, figs. 28, 29, 27, part of 17, and part of 26 respectively.

6, 7—*Petrascula globosa* Altheim. Upper Jurassic (Malm) of Bukowna, *6*, Impression of a nearly complete individual, ×3; after Pia, 1920, pl. 7, fig. 13. *7*, Cylindrical portion and transition to the upper globe, ×11; upper part is longitudinal break, while the lower is an outer view of central part with cylindrical break across fossilized branchlets; after Pia, 1920, pl. 7, fig. 9.

8—*Diploplora annulata* Schafhäutl as identified by Pia, from Ladinic (middle Triassic); after Pia, 1912, pl. 7, fig. 3, ×10 (enlarged here from original drawing, ×6). Possibly referable to *Permopora*.

elliptical, with a cortical zone made by short basal segments of somewhat unstable size and shape and with numerous much smaller subspherical or pyriform stalked structures located between sterile segments and resembling aplanosporangia of *Neomeris* and *Acetabularia*.

The genus has various features in common with several known Triassic and Jurassic genera of Dasycladaceae, but differs from them all by the internal pairing of whorls of branchlets, caused by the development of annulations on the stem.

The development of structures suggestive of fructification is the first observation of the kind in Paleozoic and Mesozoic Dasycladaceae, and the location, shape and size of the fruiting structures are very suggestive of aplanosporangia in living *Neomeris*, which means that the mode of fructification in these green algae, as far as the fruiting receptacle is concerned, apparently became established at least as early as Permian time and has not changed since. This observation is in harmony with the known similarly early and even earlier (Devonian) establishment of the spirally sculptured oval oögonia of Cheraceae, another important order of green algae.

Among previously known highly developed Paleozoic algae there is none with which *Permopora* could be compared and placed in the same genus, but there are many Mesozoic genera which resemble it to greater or less extent. Thus *Permopora* may be said to possess a Mesozoic aspect, that is its evolutionary advance resembles that of Mesozoic forms. The peculiarity that makes it look so is the arrangement of its lateral branchlets in regular whorls, and the regular checkerboard alternation of branchlets in neighboring whorls. Pairing of whorls is also a rather common Mesozoic character, but it is interesting that, contrary to its unusual manifestation on the outer surface of the cortical region or "jacket" in Mesozoic forms, in *Permopora* it is observable only on the inner surface of the "jacket," while it is not expressed at all on its outer surface. This internal pairing of the whorls in *Permopora* is connected with the development of annulations between the bases of the branchlets, one after every other whorl. Although annulated stems are recognized in some genera of Mesozoic Dasycladaceae, the annulations resulting from pairing of the whorls, as observed in *Permopora*, is apparently not duplicated in any of the Mesozoic genera known to date; however, one specimen referred by Pia to *Diplopora annulata*, but which perhaps does not belong with it, seems referable to *Permopora* (see discussion below).

The following Mesozoic forms approach *Permopora keenae* in various degree. *Conipora clavaeformis* d'Archiac (Pia, 1927, fig. 63, p. 79) from the middle Jurassic has paired whorls of branchlets along its cylindrical part, but the pairing is external, the pairs being separated by narrow smooth intervals, while no annulations on the stem between their bases is observable. *Physoporella praealpina* Pia (1912, fig. 11 on p. 54 and pl. 3, fig. 6) from Anisic (middle Triassic) has a regular checkerboard alternation of the branchlets in successive whorls, but again there are external smooth narrow intervals between the successive paired whorls, and there are wider intervals also between the groups made of four branchlets. The Anisic (middle Triassic) *Teutloporella triasina* Schauroth (Pia, 1912, pl. 4, fig. 16) differs from *Permopora* in the same and other respects. *Oligoporella pilosa* Pia of the same age (Pia, 1912, figs. 14 and 15 on p. 43) has annulations on its stem that are comparable to those of *Permopora*, but in this form, the verticils of branches are given off at the summit of each annulation, and not in the grooves between them. *Petrascula globosa*, (Pia, 1920, pl. 7, figs. 9, 10, 14) from the Malm (upper Jurassic) is very similar to *Permopora* (see my text figs. 6, 7) but it has a less regular disposition of the branchlets in the adjacent whorls, the pairing of the whorls is manifested on the outer surface of the jacket, and no annulations on its stem have been observed. On the other hand, a specimen from the Ladinic (middle Triassic) which was referred by Pia to *Diplopora annulata* Schafhäutl and illustrated on his sketch (Pia, 1912 pl. 7, fig. 3), is remarkably similar to *Permopora keenae*, but not so is the description of *Diplopora annulata*, or other illustrations and the restoration (Pia, 1912, fig. 21 on p. 48) of this species. For instance, the restoration by Pia shows no annulations on the stem, while the branches are shown

arranged in regular cross-shaped clusters of four, a feature very typical for *Diplopora* and other genera of Pia's group Metaverticillatae, the most advanced of all fossil Dasycladaceae. On the other hand, on Pia's (1912, pl. 7, fig. 3) sketch which is here reproduced as text fig. 8, there are no indications of clustering of branchlets in fours, though annular flanges suggestive of the same in *Permopora* are shown. Furthermore, the distinct arrangement of branchlets in the neighboring whorls in alternate checkerboard fashion, as well as the number of branchlets in a whorl, and all the dimensions of the spacing, are so close to those in *Permopora* that the identity of Pia's specimen with the latter may be provisionally suggested, and it seems almost certain that his specimen does not belong to *Diplopora*. The specimen is described in Pia's explanation of the plate as "Ausgewittertes Schalenfragment" viewed from inside. Its exact locality is unknown, but the formation to which it belongs is indicated in the text as "1. Wettersteinkalk der Höllengebirges," and is placed above the Muschelkalk and below the "Obertrias" in the correlation chart on p. 59.

PERMOPORA KEENAE Elias, n. sp.
Plate 18, figs. 1–11

The fossil is found in the form of casts in cavernous dolomitic limestone. The cavernous matrix fills the core of the cylinder, which is from 2 to 4 mm. in diameter, and is surrounded by a cortical region about 0.25 mm. thick, which is nearly filled with casts of short and thick upright basal segments of the lateral appendages, or branchlets, arranged in whorls. Cross sections of the casts of these segments are circular at their bases, but gradually become hexagonal (rarely rectangular) on the facets at the outer surface of the cortex.

Ordinarily, the fossilized individuals break along the porous cortex, that is across the branchlets in it, so that on the positive (convex) side of a break the basal parts or "stumps" of branchlets are seen, while on the negative (concave) side the hexagonal, proximal parts of branchlets are seen. The hexagons are usually more or less equilateral, but in many fragments the hexagons of the facets are laterally narrowed, and, besides, are not always arranged in a perfect checkerboard regularly, but occasionally the segments in the succeeding rows are located one above the other, and their outline becomes subrectangular instead of hexagonal.

On the positive, or inner side of a break, the circular "stumps" are arranged in regular rows, each pair of rows being separated from the next pair by a narrow transverse flange or annulation, while the narrow space between each two rows of a pair is slightly depressed. The spacing between the centers of the rows of "stumps" is of course the same as that between the rows of "hexagons" on the negative side of a break, subject to a gradual increase in outward, radial direction.

No single individual among those collected represents a complete plant, but all are fragments, large or small. In order to find the relationship of the fragments to each other and thus to the whole plant, they were studied in considerable detail and the following structural elements were measured in each: outer and (whenever possible) inner diameter of cortical cylinder; number of branchlets in a whorl; width and height of facets. In the longer fragments these elements were measured twice, at the narrower and at the wider ends of a fragment, in order to determine the rate of apparent change of diameter along the length of the thallus. In addition, the total length of a fragment and the total number of whorls in each were measured and counted. The features thus obtained are interdependent and thus provide a means of checking the correctness of the mensuration. The result of the measurement of 11 individuals are entered in the table in the order of the size of diameter, with the largest at the top. The measurement of the singular fruiting individual is placed directly above the sterile individual No. 3, to the distal end of which it was probably attached (see explanation of pl. 18, figs. 8–10). If this deduction is correct, the development of the elliptical fertile terminal stage may have taken place when the cylindrical sterile stage was reaching about 3+mm. of outer diameter, but, on the other hand, the plant apparently might have continued to develop its sterile cylindrical stage to 4.6 mm. diameter (the largest observed) without reaching the fertile stage.

The sterile cylindrical stage was increasing in diameter very slowly, about 0.5 mm. per 22–23 mm. of length. The restored total length of a plant which increased from 2 mm. diameter (the smallest observed) to 4.6 mm. (the largest observed), would be, at this rate of increase, about 12 cm. in length, not counting a possible terminal fertile stage. The observed fertile stage, as surmaturity, varying from 145μ at 2 mm. diameter, to 250μ at 4.6 mm. diameter. Thus the facets are decidedly more elongate near the base than near the apex of the plant, where they become nearly equilateral hexagons, or become even slightly wider than high.

Restoration.—It is customary to illustrate fossil genera and species of Dasycladaceae

DIMENSIONS OF FRAGMENTS OF PERMORPORA KEENAE ELIAS

Arranged in order of decreasing diameter

Specimen		Diameter in mm.		Number of branches in a whorl	Dimension of facets in μ		Total number of whorls	Total length in mm.	Notes
Number	Part	Outer	Inner		Width	Height			
7904.5	Distal	4.6		54	250	215	84	18.	
	Proximal	4.2		54	240	225			
7904.6	Distal	4.4		56	240	220	77	18.	
	Proximal	4.0		56	225	235			
7904.8	Distal	4.0		56	225	225	56	12.3	
	Proximal			56	200	210			
7904.7	Proximal	3.9		abt. 54	220	240	67	16.	
7904.4	Distal	abt. 5.		abt. 50	300	300	20–21	4.	Elliptical fertile stage
	Proximal	abt. 3.		abt. 50	200	200			
7904.3	—	3.3	2.8	54–56	210	230	8	2.	
7904.2	Distal	3.0		54	175	222	24	5.3	Holotype
	Proximal	2.8		54	165	222			
7905.10	—	2.8	2.5	48	185	215	28	6.	
7906.9	—	2.5		48	165	220	13	2.9	
7904.1	—	2.5	2.2	44	180	215	20	4.3	
7904.11	—	2.2		44	145	250			

mised, developed on top of a smaller plant, some 6 cm. long and 3.3 mm. in diameter, and is about 4 mm. long or slightly longer. The number of branchlets in a whorl varied from 44 to 56, with a general, but not very regular increase in number toward the upper, mature part. The distance between the whorls, which determines the height of the facets, varies from 215 to 250μ throughout the length of the cylindrical stage, keeping mostly about 215–235μ. The width of the facets, though about as variable, nevertheless generally tends to increase with

by a drawn restoration of complete adult plants (Pia). Although a similar restoration might be attempted for *Permopora* on the incomplete evidence of the material here described, it seems prudent to postpone the attempt because a determined search at the localities from which Beckwith collected may result in the discovery of better, more complete specimens of *Permopora*, which will allow its more precise restoration.

In the meantime, the single fertile fragment (pl. 18, figs. 8, 10) is provisionally regarded as terminal upon the cylindrical

sterile stage of *Permopora* (see explanation to pl. 18, figs. 8–10) and it is suggested that its sterile cylindrical stem increased very slowly in diameter, from about 2.2 mm. or less at the base to 4.6 or more at the apex. Correlated with this increase in size was a general tendency to change from much elongated facets below to more nearly equilateral hexagonal facets above.

STRATIGRAPHIC AND EVOLUTIONARY SIGNIFICANCE OF PERMOPORA

The occurrence of the highly symmetrical Mesozoic-like green alga *Permopora* in the upper Permian of Texas is so surprising that one might wonder whether the whole Custer group, near the base of which it belongs, may not be of Triassic rather than of Permian age. In fact this suggestion has been made already by Roth (1932) on the basis of Custer marine invertebrates and some stratigraphic considerations, but a later detailed description and analysis of these fossils by Newell, Knight, Brill and Moore (1940) convinced them that they are of later Permian age. Indeed, if the Custer is correctly correlated with the Carlsbad lithologic facies of the Capitan, as most geologists hold, its Permian age seems beyond dispute. But if so, then the presence in these beds of *Permopora* introduces substantial correction to the scheme of evolution of the fossil Dasycladaceae as worked out by Pia. According to Pia's scheme the Paleozoic cylindrical Dasycladaceae were covered with densely but *irregularly* disposed branchlets, while their arrangement in whorls was an advanced condition reached only in Triassic time. Although the discovery of whorled Dasycladaceae in very late Permian strata may seem merely a slightly earlier development than that previously supposed by Pia, more upsetting is the fact of the rigid pairing of the whorls by annulations and the very regular checkerboard arrangement of the branches in the neighboring whorls in *Permopora*. If we accept the evolutionary law for Dasycladaceae advanced by Pia, according to which the general progress was from an irregular to a regular arrangement of branches, then we must consider that *Permopora* achieved a very high level of regularity in the arrangement of its branches much earlier than the rest of the Dasycladaceae, which reached a similar evolutionary stage only in middle Triassic or even later Mesozoic ages. Such a conclusion, which indicates an unequal rate of evolutionary advance in genetically related branches, would not be very unusual, because somewhat similar cases are known in the evolution of some ammonites, fusulines, and other marine invertebrates.

Among other characteristic features of *Permopora*, the large number of appendages in a whorl seems to be a primitive feature, which this genus shares with *Anthracoporella*. The very small length as compared with the width of the basal segments and their very large scars on the stem may be also rather primitive features.

In a search for previously described Paleozoic symmetrical green algae, that could possibly be related to *Permopora*, I have had an opportunity, through the courtesy of Dr. R. S. Bassler, to examine the specimens of *Nidulites*, *Cerionites* and *Pasciolus* in the collections of the United States National Museum. Unfortunately insufficient preservation of structural details in these early Paleozoic forms prevented detailed comparison, but it appears that there is no evidence of verticillate arrangement of appendages or annulations on the stem in *Nidulites* (pl. 18, figs. 12–14), which is better preserved than the other two genera in the collection of the National Museum.

On the other hand, the regular checkerboard arrangement of their facets, which are equilateral hexagons, is suggestive of the same in the fertile stage in *Permopora* (pl. 18, figs. 8, 10). If *Nidulites* belongs to a stock ancestral to *Permopora*, which seems possible, then the arrangement of appendages or branchlets in clear-cut whorls, in the proximal (but not in the distal, fertile) part of the plant, apparently evolved in post-Ordovician time. It appears that in *Nidulites* fertile and sterile stages were not differentiated, and only subsequently the development of aplanosporangia became localized in the distal, upper part of the plant. If so, the distal part in *Permopora* preserved an ancient arrangement of facets, while the proximal part, which became sterilized, developed transverse differentiation manifested by the arrangement of branchlets in clear-cut whorls, and by the pairing of

whorls by annulations on the stem. Besides, the whole plant and its appendages became proportionally smaller in late Paleozoic time.

RELATION BETWEEN PROGRESS IN METHODS OF STUDY, BIOLOGICAL UNDERSTANDING, TAXONOMIC TREATMENT, AND STRATIGRAPHIC USEFULNESS OF FOSSILS

The radially-symmetrical, small to microscopic fossil algae, whose, size, general configuration and mass occurrence resemble so much those of fusulines, undoubtedly could be utilized to better advantage in the correlation of late Permian and younger rock formations than has yet been done. The way toward better utilization is through improved technique in field collecting and preparation, which would be followed by improved biometric studies and standardized manner of illustration. Just as the study of a larger number of specimens naturally or artificially liberated from rock matrix, oriented sectioning, detailed investigation of anatomy, and standardization of mensuration resulted in refined differentiation into genera and species and the establishment of more restricted stratigraphic range among the fusilines, so improved field and laboratory handling of the radially-symmetrical fossil algae is likely to result in their better classification and more precise stratigraphic use. No doubt, the lifelong efforts of Pia, who specialized on Dasycladaceae and other fossil algae, helped greatly in the recognition of their stratigraphic value and resulted in better understanding of their nature. But a paleontologist who attempts to identify the genera and species in his own material finds the drawings and reconstructions difficult to compare with, and the diagnostic features difficult to recognize. Only a part of this difficulty is due to the complexity of the fossils, whose anatomy, after all, is not as complex as that of fusulines. The greater part of the difficulty is decidedly due to a combination of imperfection of preservation, irregularity of sectioning, and insufficient understanding of morphology and of anatomy, which are now being customarily illustrated by camera lucida sketches and generalized reconstructions, the magnifications of which, besides, is far from standardized (all kinds of odd scales are used).

One might suppose that perhaps the imperfection of preservation precludes the possibility of an improvement of the whole technique of investigation, so that what Pia accomplished with the material at his disposal is the best that can possibly be done with these fossils, and only little improvement over his results may be generally expected. However, the following circumstances, which handicapped Pia's work, must be taken to account. His work with the fossil algae was not conducted on a sufficiently large scale as part of an organized utilization of fossils in precise surface and subsurface correlations, as is now done in America and lately also in Russia. Also, apparently, he did not attempt a determined search for particular specimens that had been weathered free from the enclosing matrix. Instead, he developed a method of reconstruction from series of various odd sections obtained by cutting or breaking the ordinary fossiliferous rock specimens available to him. The accuracy of such reconstructions obviously depends on the character of the preservation and the abundance of the material collected, and, particularly, on the author's understanding of the fossil that he attempts to reconstruct. Thus his reconstructions frequently reflect rather stages in a progressive understanding of a fossil, and do not necessarily illustrate its actual structure, correct in all details. A change in Pia's interpretation of the stratigraphically important late Permian form *Gymnocodium bellerophontis* is very instructive in this respect and is also of practical importance for American stratigraphers and paleontologists because this species is likely to be found in our late Permian rocks. In an earlier comprehensive paper by Pia (1912) the species is classified as *Macropora bellerophontis*, a dasyclad, and is illustrated by about as many sketches of varied unoriented sections as most other species described; also a reconstruction of the alga is given in some detail and on a scale similar to that used in the reconstruction of other forms. However, Pia admitted encountering some difficulties in reconstruct-

ing the species *M. bellerophontis* from its sections. He pointed out its apparent variability and imperfection of preservation, which complicate its interpretation and hence the reconstruction. In his later publications (1920, 1927) he admits the error of the original restoration of this form, erects for it a new generic name *Gymnocodium*, removes it entirely from Dasycladaceae, and places it in Codiaceae. Although Dasycladaceae and Codiaceae are both green algae not very distantly related, this shift in taxonomic standing has not merely an academic interest but indicates a drastic change in the interpretation of its important anatomic feature, the structure of the wall of the stem. In the original (1912) restoration the stem was visualized as a thin and structureless cylinder, around which grows a cortical region made of numerous closely set and equal lateral branches, radiating with an appreciable upward inclination. These inclined lateral branches were supposed to terminate in somewhat convex apical plates, from which branches of a second order were given off (as in other Dasycladaceae). In the new restoration, however, the wall of the stem is viewed as thick and perforated, and includes all the thickness of the cortical region, which formerly was supposed to be made by radiating branches. What was visualized as branches is now interpreted as radiating perforations within the thick cylindrical wall. Thus, the original reconstruction of the form (Pia, 1912, fig. 3 on p. 34) is no longer tenable, and Pia (1920, 1927) makes no reference to it in his new descriptions of the form.

Another Permian species, understanding of which became confused, is *Stolleyella yabei* Karpinsky, which was named, described and illustrated (Karpinsky, 1908, p. 269, and text figure with explanation on p. 268) as a form with an oval cross section, and a cylindrical (not oval) outline. Pia subsequently erroneously describes and refers to Karpinsky's species a Permian form with an oval outline and circular cross section, which is correctly placed by him in the genus *Mizzia*, but which is certainly not identical with Karpinsky's species *S. yabei*. This misunderstanding apparently arose because Pia did not follow the method introduced by Karpinsky for the study of the symmetrical fossil green algae, and which consists of a combined study of individuals completely liberated from matrix, and of oriented sections of the same. The superior, more nearly complete understanding of the morphology and anatomy of the fossil forms that is gained by this latter method makes it possible to understand and interpret correctly the numerous unoriented sections of comparatively undamaged specimens, or even of the crushed specimens and their fragments that are most frequently obtained in casually collected and subsequently broken or cut bulk material (see Karpinsky, 1908, pp. 263–266, text figs. 1–5). Indeed, under certain circumstances, such imperfect material may be all that is available to a paleontologist, who may be compelled to identify the fossils from it, but this is not material on which new fossil forms can be satisfactorily studied, named and described. Unfortunately, nearly all genera and species erected by Pia are based on such imperfect material and unoriented sections, and this is the source of difficulties and confusion in identification of these forms. Perhaps the method of study employed by him was inevitable when handling various random-collected specimens with fossils firmly imbedded in the matrix, but an advanced study of fossil Dasycladaceae for use in precise correlations of rock formations, as now demanded by highly developed economic geology, makes a return to the method inaugrated by Karpinsky imperative. There is an abundance of well-preserved fossil material in American Permian rocks which allows the use and elaboration of such advanced methods. Application of this method is likely to result in a better understanding of the biologic nature, life habit, and evolution of fossil Dasycladaceae and will consequently lead to a clearer and more stabilized taxonomy, and through all this will make these fossils more useful in economic geology.

REFERENCES

BEEDE, J. W., 1907, Invertebrate paleontology of the upper Permian red beds of Oklahoma and the Panhandle of Texas: Kansas Univ. Science Bull. vol. 4, pp. 115–171, pls. 5–8.

CHURCH, ARTHUR H., 1895, The structure of the thallus of *Neomeris dumetosa* Lamour.: Annals of Botany, vol. 9, pp. 581–608, pls. 21–23.

HOWE, M. A., 1909, The genus *Neomeris* and notes on other Siphonales: Torrey Bot. Club Bull., vol. 36, pp. 75–104, pls. 1–8.

JOHNSON, J. H., 1942, Permian lime-secreting algae from the Guadalupe Mountains, New Mexico: Geol. Soc. America Bull., vol. 53, pp. 195–226, pls. 1–7, 5 text figs.

——, and DORR, M. E., 1942, The Permian algal genus *Mizzia:* Jour. Paleontology, vol. 16, pp. 63–77, pls. 9–12.

KARPINSKY A., 1908, Einige problematischen Fossilien aus Japan: Russ. K. min. Gesell. Verh., ser. 2, Band 46, pp. 257–272, 6 text figs., pl. 3.

NEWELL, N. D., *et al.*, 1940, Invertebrate fauna of the late Permian Whitehorse sandstone: Geol. Soc. America Bull., vol. 51, pp. 261–336, 10 pls. 11 text figs.

PIA, JULIUS, 1912 Neue Studien über die triadischen Siphoneae verticillatae: Beitr. Paläontologie Österr.-Ungarns u. des Orients, Band 25, pp. 25–81, pls. 1–8.

——, 1920, Die Siphoneae verticillatae von Karbon bis zu Kreide: Zool.-bot. Gesell. Wien Abh., vol. 11, pt. 2, 263 pp., 8 pls., 27 text figs.

——, 1927, Thallophyta (in HIRMER, MAX, Handbuch der Paläobotanik) 136 pp., 129 text figs.

ROTH, ROBERT, 1932, Evidence indicating the limits of Triassic in Kansas, Oklahoma and Texas: Jour. Geology, vol. 40, pp. 688–725, 3 figs., 2 pls.

——, 1937, Custer formation of Texas: Am. Assoc. Petroleum Geologists Bull, vol. 21, pp. 421–474, 15 figs., 11 maps.

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ANALYSIS AND REVISION OF ELEVEN LOWER CAMBRIAN TRILOBITE GENERA

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ABSTRACT—In attempting to describe a Lower Cambrian fauna recently, I found much confusion in the literature concerning the generic and specific determinations of the North American Lower Cambrian trilobites. A lack of careful descriptive work combined with the poor preservation of much of the type material has rendered both paleontologic and stratigraphic work in the Lower Cambrian most difficult and uncertain. A clarification of the diagnostic generic characters of each of the described genera, as indicated by the types of the type species is imperative. Eleven genera are analyzed in this paper—*Antagmus*, *Bonnia*, *Litocodia*, *Onchocephalus*, *Periomma*, *Periommella*, *Plagiura*, *Plagiurella*, *Proliostracus*, *Ptychoparella* and *Syspacephalus*. All the published species of these genera have been checked for correct generic identification and are listed as to their correct position. *Litocodia* Resser, 1938, is a synonym of *Antagmus* Resser, 1936, and *Plagiurella* Resser, 1937, of *Plagiura* Resser, 1935. Two new genera, *Crassifimbra*, genotype *Onchocephalus walcotti* Resser, and *Piaziella*, genotype *Ptychoparia pia* Walcott, are described. Since the present revision shows that *Syspacephalus* is known only from the genotype material from one locality in British Columbia, it is proposed that the uppermost Lower Cambrian faunal zone of North America be called the *Antagmus-Onchocephalus* zone (for the two most common genera) rather than the *Syspacephalus* zone.

INTRODUCTION

RECENTLY I undertook to describe a small fauna of Lower Cambrian trilobites, which, exclusive of the Olenellidae, appeared to contain only a few genera and species. An attempt to place these few forms correctly with reference to previously described North American genera revealed complete confusion in the literature as to the diagnostic generic characters of most of the genera. The establishment of genera without clear-cut generic characters, the careless assignment of species to the genera, and the use of fossil material too poor for description, all appear to have been important factors contributing to this confusion. I have had to reëxamine most of the genera and species of the American Lower Cambrian trilobites, exclusive of the Olenellidae, to make these revisions. Fortunately most of the type specimens are at the United States National Museum, and types deposited at other museums are represented there by good plaster casts.

The examination of all this material failed to reveal any good reason for the establishment of Lower Cambrian genera and species on a different combination of generic and specific features than those used for the recognition of Middle and Upper Cambrian trilobites. Cambrian students have not previously stated the principles they were following, and it is frequently impossible to determine them from their descriptions. Accordingly, I am listing and discussing below the combination of features which I consider to be generically diagnostic as well as those features which I regard as constituting valid specific differences. It is important to note not only the diagnostic generic features but also the diagnostic specific ones, as it was found that specific features had been frequently but not consistently used as of generic value, and specific differences were then based on features clearly attributable to preservation or individual variation, or else simply locality differences. The present chaos definitely indicates that a set of generic and specific standards must be established, recognized, and adhered to by all Cambrian trilobite students, or else this group of fossils will lose all paleontologic and stratigraphic value and be thoroughly discredited. These lists of diagnostic generic and specific features are presented with the hope that other Cambrian stu-

dents will critically evaluate them so that a standard may be established as a guide for future work.

DIAGNOSTIC GENERIC FEATURES

In the following tabulation the features of the cranidium are given first, and much greater emphasis is placed upon them than upon the features of the pygidium. Ideally, all parts of the carapace should contribute to the complete generic diagnosis, but it so happens that the majority of the Lower Cambrian genera considered are known only from cranidia. Experience seems to indicate that the cranidium does reveal the most fundamental distinctions in this group, although the characters of the free cheek, thorax and pygidium should always be considered when these parts are available. In most Lower Cambrian and many Middle Cambrian trilobites where these other parts are known, they show much less variation than the cranidium. But there are a number of valid Middle Cambrian genera in which the pygidia furnish the important generic features; and in Upper Cambrian trilobites the cranidium and pygidium are both frequently generically distinct.

The following six diagnostic generic features of the cranidium are listed and discussed. It is believed that a definite, recognizable variation in any one of these features constitutes a valid generic distinction. Changes should be coarse enough to be measurable with a millimeter scale; very small variations in these features cannot be regarded as generically significant.

1. Length (or size) of palpebral lobe—and the position of its midpoint with reference to that of the glabella.
2. *a*, The basic shape and the convexity of the glabella. *b*, The definite presence or absence of glabellar furrows, their number, and direction, this is an important feature, and may well be one of the few features of the trilobite dorsal carapace which reflects a fundamental body structure, but I cannot emphasize too strongly its careful handling in generic diagnosis as the strength of the furrows is most frequently influenced by preservation. (Lochman and Duncan, 1944, p. 28, pl. 17, figs. 5, 10.)
3. Proportional width of fixed cheeks to glabella, measuring both on a line through their respective midpoints.
4. Position of the fixed cheeks with reference to a horizontal plane through the dorsal furrow. Five positions are recognized: elevated (45° or more above), upsloping (20°± above), horizontal, downsloping (20°± below), depressed (45° below) (rare). This feature is the most difficult one to determine as allowance must be made for the curvature of the fixed cheek, the estimated position of the horizontal plane, and the effect of the preservation. A truely accurate determination can be made only on a well-preserved limestone specimen; and where the angle of divergence is quite slight, it is difficult to decide just how to classify the slope.
5. Width and length of the posterolateral limb. It has been found convenient to compare the length of the posterolateral limb with that of the occipital ring, and the width with reference to the side of the glabella.
6. General structure of the preglabellar area. The majority of Cambrian trilobites have a generalized area made up of a frontal limb, a frontal border, and a separating marginal furrow. Consequently, in most genera this feature has no generic value but, as noted below, variations in this generalized type of preglabellar area within the genus are regarded as an important specific criterion. However, striking major structural changes are readily recognized and are of generic importance.

As stated above the pygidium of the Lower Cambrian trilobites is quite poorly known, and in most of the genera where it is known it is a small, moderately transverse, generalized type with little or no value in revealing generic distinctions. The following three diagnostic generic features of the pygidium are listed and discussed:

1. Outline (shape) and convexity of pygidium; presence and character of marginal spines.
2. *a*, Proportion of pleural lobe to axial lobe measured along the anterior margin. *b*, Presence or absence of marginal furrow. *c*, Basic character of marginal border.
3. Basic structure of axial lobe; basic structure of pleural lobe

DIAGNOSTIC SPECIFIC FEATURES

The features of the cranidium and the features of the pygidium that are considered valid for specific diagnosis are listed below. Of the four features of the cranidium I regard the first as furnishing the most important specific variations, and believe it can be used unerringly. Features 2 and 3 involve valid though minor distinctions, but as they can be seriously affected by the preservation, they should be used cautiously, and are best when many specimens are available. Feature 4 has specific value in current usage,

but I doubt whether its true biologic value is specific in nature.

1. Variations in width, convexity and slope (position) of the frontal limb and the frontal border, and in the depth, width and direction of the marginal furrow. Variation in any one of these features in five or more well-preserved limestone specimens appears to constitute a fully valid specific distinction.
2. Minor variations in the convexity, width and length of the glabella. Care must be taken that these variations are minor (not in the realm of diagnostic generic feature 2), and yet are not caused by preservation alone. A suite of five or ten specimens should be available.
3. Minor variations in width and convexity of the fixed cheeks. The same care must be observed as for feature 2.
4. Presence and size of the occipital spine or node

The four features of the pygidium that are used for specific diagnosis are listed below.

1. *a*, Variations in the direction and size of the marginal spines. *b*, The number of marginal spines—in some genera the number is so constant that this is an additional valid generic feature, but in other genera it appears to be only of specific value.
2. Minor variations in the strength and width of the marginal furrow, minor variations in the width and convexity of the marginal border.
3. Presence or absence, number, and arrangement of spines or nodes on the axial lobe and on the pleural lobes.
4. Variations in the number and strength of segments on the axial lobe and the pleural lobes. This feature demands considerable care in its use as it may be markedly affected by the preservation. As in feature 1, the number is so constant in certain genera as to be of generic value, but in other genera it appears to be only of specific value.

Ornamentation cannot be considered as a feature of the trilobite carapace which has either generic or specific value because it is most seriously affected by preservation, either by abrasion of the outer surface before burial; by subsequent vagaries of replacement; or by the fact that many specimens are only internal molds. Moreover, in all the Cambrian trilobites that I have observed, exclusive of the Olenellidae, there are only a very few types of ornamentation, and these few occur over and over again without any regard to generic or specific distinctions, though generally all members of one genus are usually the same. It is difficult to evaluate ornamentation because many paleontologists have been careless in distinguishing whether they are dealing with good outer surfaces, good inner surfaces, worn surfaces or simply molds.

From my personal observations the following types can be recognized on the outer surface of test:

1. Entirely smooth.
2. Smooth with a few narrow ridges along marginal border of cephalon.
3. Granulated: *a*, in one size granules, with or without narrow bordering ridges; *b*, in two sizes of granules, with or without narrow bordering ridges; *c*, in three size granules, with or without narrow bordering ridges.
4. Marginal slots (in Agnostida only).
5. Coarse pitting (in Agnostida only).
6. Reticulation (in Agnostida only).

The Olenellidae exhibit two types of ornamentation, one producing a reticulate pattern and the other a granulate pattern, which are totally different from the types found in the other trilobites.

The following types of ornamentation can be recognized on the inner surface of the test:

1. Smooth
2. Punctate, the size of the punctae ranging from very fine to coarse.

It should also be noted that on the inner surface lie the thick anastomosing venations that radiate from the eyes out over the free cheeks and from the front of the glabella over the frontal limb. If very coarse, the venations show through on the outer surface. I wish to emphasize that this feature is not ornamentation, though frequently described as such; but rather it appears to be the impress of an internal anatomical structure on the carapace. As it has been observed in many apparently unrelated genera ranging through the Paleozoic, it is considered to be a feature characteristic of the whole class.

PRESERVATION

A second factor that was considered carefully in making this revision is the amount of allowance to be made for the condition of preservation. Much of the type material is quite obviously poorly preserved. Some of this is the fault of the original collectors and the extremely small size of the collections. However, several other factors are

apparently also responsible. Much of the Lower Cambrian material occurs in shales and shaly limestone in the form of flattened, distorted shale molds. Where the distortion is large, it is easily detected; but much more frequently the shale of the molds appears to have yielded without cracking, and these small distortions are hard to detect and to estimate. Moreover, it seems to me, after working with Upper Cambrian trilobites, that the carapace of the Lower Cambrian specimens is actually thiner and weaker than that of the Upper Cambrian forms, and, so, much more susceptible to losing its shape and convexity upon burial.

ANALYSIS OF ANTAGMUS, LITOCODIA, ONCHOCEPHALUS, AND SYSPACEPHALUS

The four apparently late Lower Cambrian trilobite genera *Antagmus*, *Litocodia*, *Onchocephalus* and *Syspacephalus* have never been clearly and distinctly defined, and consequently considerable confusion as to their exact generic characters appears to have occurred. This uncertainty led to many mistakes in generic assignment and finally to the naming of the uppermost Lower Cambrian faunal zone, the *Syspacephalus* zone, although, as the present revision shows, *Syspacephalus* is known only from the genotype, *Syspacephalus charops* (Walcott) occurring at one locality on Mount Stephen, British Columbia. Actually the two genera *Antagmus* and *Onchocephalus* are the forms that are widely distributed throughout the United States in this uppermost Lower Cambrian zone. I now propose that this zone be called the *Antagmus-Onchocephalus* zone.

The Lower Cambrian opisthoparian trilobites involved in this revision all present a rather simple and generalized cranidial structure, and it often appears that lateral gradations from one genus to another may exist. Such a situation could be attributed to the probable primitive condition of the genera, and it might well be argued that only a few broad genera of Lower Cambrian trilobites should be recognized. Past experience indicates that true broad relationships can be obtained only when large suites of accurately located material are available; but the present stratigraphic knowledge and fossil material of the Lower Cambrian is so limited that it is not now possible to determine just what such broader generic limitations should be. I believe that the recognition of sharply delimited, clear-cut features for each genus and the insistence that each species adhere strictly to the generic qualifications will at least have the advantage of pointing up the stratigraphic significance of the various forms, and may well, in the long run, clarify the biologic relationships.

The following revisions give first a full and exact analysis of the cranidium of each genus, based upon the holotype and paratype material of the genotype, and, whenever possible, an analysis of the pygidium. However, for most genera only the cranidium has been described for these genera. Second, a list is given of all the described species which satisfy the generic features of each genus and so belong in that genus. A thorough revision of the species has not been undertaken at this time, but certain obvious synonyms are indicated.

ANALYSIS OF ANTAGMUS RESSER (1936, P. 3)

Genotype, *Antagmus typicalis* Resser = *Ptychoparia teucer* Walcott not Billings, whose holotype is USNM 15436.

1. Palpebral lobes small, very slightly back of midline of glabella.
2. Glabella conical with nearly straight front, regular convexity, three short glabellar furrows, of medium strength.
3. Fixed cheeks two-thirds width of glabella on midline.
4. Fixed cheeks horizontal.
5. Posterolateral limbs starting even with posterior third of glabella, length very slightly less than or the same as the occipital ring.
6. A frontal limb, a frontal border expanding posteriorly on median line, causing a median inbend of the marginal furrow.

The described species that adhere to these generic features are:

Antagmus typicalis Resser.

Antagmus tennesseensis Resser.

Inglefieldia perola (Walcott). This species is represented by many specimens flattened in shale. The palpebral lobes are obviously too small for *Inglefieldia*, but distortion makes it hard to be sure of the shape and convexity of the glabella and of the proportions of the fixed cheeks. In the latter,

measurements vary somewhat but most give a ⅔ proportion.

Litocodia typicalis Resser = *Antagmus tennesseensis* Resser (see below).

Ptychoparella adamsi (Billings). A large number of cranidia represent this species in the U. S. National Museum; all belong to *Antagmus* and represent a distinct species characterized by a frontal limb slightly wider than the medium wide frontal border, both convex and having a smooth continuous downward slope, steepening slightly in border, and a well-defined marginal furrow. The following material belongs here: USNM 111595, casts of holotype cranidium, N.M.C. 429; USNM 111598, duplicate cranidia from type locality; USNM 111597, three cranidia labeled *Ptychoparella vulcana* (Billings).

Ptychoparella buttsi Resser—a valid species.

Ptychoparella lancastra Resser. All specimens are badly distorted, but measurements taken on a fair impression indicate that it belongs to *Antagmus* and represents a distinct species.

Ptychoparella billingsi Resser = *Ptychoparella adamsi* (Billings), laterally distorted.

Antagmus? simplex Resser. This species is represented by two poorly preserved cranidia on which it is very hard to take measurements. The cranidia check in most features, but the palpebral lobe seems to be slightly longer and the width of the fixed cheeks gives a proportion of ¾ rather than ⅔. Such a combination of features is not known in any described genus, but I am unwilling to attach generic significance to these discrepancies until better material is available.

ANALYSIS OF LITOCODIA RESSER
(1938, P. 86)

Genotype, *Litocodia typicalis* Resser, whose holotype is USNM 94768.

1. Palpebral lobes small, very slightly back of midline of glabella.
2. Glabella conical with nearly straight front, convexity not known, glabellar furrows apparently not preserved.
3. Fixed cheeks two-thirds width of glabella on midline,
4. Not determinable.
5. Posterolateral limb starting even with posterior third of glabella; length very nearly same as that of occipital ring.
6. A frontal limb, a frontal border expanding slightly posteriorly on median line, causing a median inbend of the marginal furrow.

The genus and species is based on one small (2¼ mm. across palpebral lobes by 2 mm. long), laterally distorted shale cranidium, which, when measured as nearly exactly as possible considering the distortion of the specimen, is generically and specifically the same as *Antagmus tennesseensis* Resser. Examination of the holotype or even Resser's figure (1938, pl. 4, fig. 27) reveals several inaccuracies in Resser's original generic description. I conclude that *Litocodia* Resser, 1938, is a synonym of *Antagmus* Resser, 1936.

ANALYSIS OF ONCHOCEPHALUS RESSER
(1937a, P. 20)

Genotype, *Onchocephalus thia* (Walcott), whose holotype is USNM 64388.

1. Palpebral lobes small, on midline of glabella.
2. Glabella conical with nearly straight front, convexity highest posteriorly sloping to low anteriorly; three short glabellar furrows of medium strength.
3. Fixed cheeks three-fourths width of glabella on midline.
4. Fixed cheeks downsloping.
5. Posterolateral limb starting even with posterior third of glabella; length the same or just a little more than the occipital ring.
6. A frontal limb, a frontal border expanding posteriorly on median line, causing a median inbend of the marginal furrow.

It should be noted that there is nothing distinctive in the shape of the frontal limb and border as Resser's discussion (1937a, p. 20) would imply, but that it is a type of preglabellar area that appears to be rather common in many Lower and some Middle Cambrian genera. The type cranidium is much worn and somewhat broken. It differs from Walcott's retouched photograph (1917, pl. 12, fig. 6) in that the marginal furrow and glabellar furrows are fainter, the ocular ridges are slightly curved rather than straight, and the left posterolateral limb is broken off. But with the holotype, there are several other better-preserved cranidia, which are definitely of the same species and help to supplement the information of the holotype.

The described species that adhere to these generic features are:

Onchocephalus thia (Walcott).

Onchocephalus parvus (Walcott). Appears to belong here, though measurements are difficult to take as the type cranidium is badly distorted.

Periomma leuka (Walcott). The cranidia are quartzite molds but are adequately represented. Walcott's photograph (1917, pl. 13, fig. 4) does not show the inbend of the marginal furrow and the glabellar furrows should be fainter.

Syspacephalus virginicus Resser. The holotype, the only known specimen, is deeply weathered and broken around the edges, but all features that can be determined indicate its position in this genus.

ANALYSIS OF SYSPACEPHALUS RESSER (1936, P. 28)

Genotype, *Syspacephalus charops* (Walcott), whose holotype is USNM 64395.

1. Palpebral lobes small, on anterior third line through glabella;
2. Glabella conical with nearly straight front, convexity highest posteriorly, sloping to low anteriorly; glabellar furrows very faint
3. Fixed cheeks three-fourths width of glabella on midline.
4. Fixed cheeks horizontal near glabella, downsloping at edges.
5. Posterolateral limb starting even with midline of glabella; length slightly less than that of occipital ring.
6. A frontal limb, a frontal border expanding slightly posteriorly on median line, causing a median inbend of the faint marginal furrow.

The surface of the type cranidium is so worn that it is hard to judge the strength of the furrows and the true outline of the cranidium; but on the same piece of rock and an associated piece, eight other cranidia of this species occur, and these show that the furrows are faint but present, and the palpebral lobes are definitely in a forward position.

The only described species which adheres to the generic features is:
Syspacephalus charops (Walcott).

COMPARISON OF ANTAGMUS, ONCHOCEPHALUS, AND SYSPACEPHALUS

Onchocephalus differs from *Syspacephalus* in the following three features:

1. Position of the palpebral lobes—on the midline of the glabella in *Onchocephalus*, but one-third the distance from the anterior end of glabella in *Syspacephalus*.
2. Posterolateral limb starting on midline of glabella, and slightly less than occipital ring in *Syspacephalus*, but starting on posterior one-third of glabella, and same length or slightly longer than occipital ring in *Onchocephalus*.
3. Course of anterior facial suture (actual significance not known) slightly divergent in *Onchocephalus*; slightly convergent in *Syspacephalus*.

Onchocephalus differs from *Antagmus* in the following two features:

1. Width of fixed cheeks—proportion is two-thirds in *Antagmus*, but three-fourths in *Onchocephalus*.
2. Position of fixed cheeks—horizontal in *Antagmus*, but downsloping in *Onchocephalus*.

Antagmus differs from *Syspacephalus* in all of the first five features.

DISPOSITION OF OTHER SPECIES REFERRED TO ANTAGMUS, ONCHOCEPHALUS, AND SYSPACEPHALUS

During the course of the analysis of the above three genera it was found that a number of species that had been assigned to one or the other of them do not have the required generic features and so must be removed from these genera.

Ptychoparia pia Walcott (1917, p. 93) was assigned to *Antagmus* by Resser. This species, represented by a number of moderately well preserved cranidia of varying sizes, presents a combination of distinct generic features that has not been found in any described genus. The features are so definite that they merit description as a new genus, herein named *Piaziella*.

Antagmus skapta (Walcott) Resser is known from only one small cranidium from which the palpebral lobes, edges of fixed cheeks, and the posterolateral limbs are broken. It is impossible to determine its generic position without more material. The species has a marked similarity to *Piaziella pia* (Walcott) in all parts of the cranidium that are known.

Onchocephalus walcotti Resser (1937a, p. 21) possesses a combination of generic features that characterize also three species referred to *Antagmus* by Resser. In *O. walcotti* the frontal limb and border are the same width, both are slightly convex and continue the same downward slope of about 45°. This species is made the genotype of *Crassifimbra*, n. gen.

Antagmus cuneus (Walcott) Resser is here referred to *Crassifimbra*. The proportion of frontal limb to frontal border is 2 to 3; the frontal limb is flat, gently downsloping; the frontal border flat, nearly horizontal.

Antagmus cleon (Walcott) Resser is referred to *Crassifimbra*. It is like *Crassifimbra walcotti* in frontal limb and border, but the glabella appears more convex and the glabellar furrows fainter. These features may be due entirely to the state of preservation.

Antagmus arizonaensis Resser, represented only by two poor quartzite molds, fits *Crassifimbra* in features 1, 2, 3, and 6, but the free cheeks appear to be more nearly horizontal, and the exact length of the posterolateral limb cannot be determined.

Syspacephalus? redpathi (Walcott) Resser is represented in the United States National Museum by specimens USNM 23839, consisting of a plaster cast of the holotype cranidium in the National Museum of Canada and a small piece of rock containing what appears to be the impression of the holotype cranidium. The position of the palpebral lobes on the midline of the glabella indicates that the species definitely does not belong to *Syspacephalus*, but as the preservation is too poor to determine most of the generic features, the species cannot be placed until better material is available.

Syspacephalus uncus (Walcott) Resser is represented by three small cranidia characterized by a combination of generic features that definitely removes the species from *Syspacephalus*. Although the species does not fit any described genus, it seems inadvisable to erect a new genus on such limited material. The generic features of this species are:

1. Palpebral lobes small, slightly back of midline of glabella.
2. Glabella parallel-sided with broadly rounded front; regular convexity; no glabellar furrows.
3. Fixed cheeks two-fifths width of glabella on midline.
4. Fixed cheeks depressed.
5. Posterolateral limb approximately four-fifths the length of the occipital ring.
6. Frontal limb apparently absent, a frontal border, a straight marginal furrow.

ANALYSIS OF PTYCHOPARELLA POULSEN (1927, P. 279)

Genotype, *Ptychoparella brevicauda* Poulsen, whose holotype is in the Copenhagen Min. Mus. Measurements taken on casts of the holotype, USNM 70924.

Cranidium:

1. Palpebral lobes just under medium, situated one-third the length of glabella from the posterior end, so ocular ridges curve far forward.
2. Glabella large, broadly conical, with rounded front; regular convexity; three pairs of medium-length, distinct glabellar furrows.
3. Fixed cheeks just over two-thirds width of glabella.
4. Fixed cheeks horizontal or slightly downsloping.
5. Posterolateral limb same length or very slightly less than occipital ring.
6. A frontal limb, a frontal border, a smoothly curved marginal furrow.

Pygidium:

1. Narrow-transverse in outline, quite short.
2. Pleural lobes same width as axial lobe, narrow marginal furrow, narrow marginal border.
3. Axial lobe same width as length, with four segments.

The described species that adhere to these generic features are:

Ptychoparella brevicauda Poulsen.

Ptychoparella kindlei Resser. Correctly placed so far as can be determined because of very poor preservation.

Ptychoparella minor Resser. Appears to be a small cranidium referable to *Ptychoparella taylori* Resser.

Ptychoparella swantonensis Resser = *Ptychoparella walcotti* Resser. The holotype is a distorted cranidium indistinguishable from those of *P. walcotti* Resser except for the distortion.

Ptychoparella taylori Resser. A valid species. In the same material as the type cranidium at the United States National Museum is the impression of a very narrow transverse pygidium of the same structure as that associated with the cranidium by Poulsen. It was not described or figured by Resser.

Ptychoparella walcotti Resser. A valid, well-represented species.

DISPOSITION OF OTHER SPECIES OF PTYCHOPARELLA

Ptychoparella adamsi (Billings) = *Antagmus adamsi* (Billings).

Ptychoparella billingsi Resser = *Antagmus adamsi* (Billings).

Ptychoparella buttsi Resser = *Antagmus buttsi* (Resser).

Ptychoparella canadensis Kobayashi. USNM 93083, casts of the cotype cranidia, NMC[1] 8714, indicate that the preservation is too poor for either accurate generic or specific identification.

Ptychoparella? gaspensis Kindle. Certainly not in *Ptychoparella*, as the fixed cheek is only one-third the width of the glabella, and the posterolateral limb is definitely shorter than the occipital ring. I do not know any described genus with this set of generic features.

Ptychoparella georgiensis Resser = *Crassifimbra? georgiensis* (Resser). The type material consists of crushed shale cephala and thoraces on which it is very difficult to take accurate measurements. The reference to *Crassifimbra* is questioned because the length of the posterolateral limbs is apparently greater though it agrees in every other generic feature.

Ptychoparella lancastra Resser = *Antagmus lancastra* (Resser).

Ptychoparella michaeli Resser. The single shale holotype cranidium is too poorly preserved for either generic or specific identification.

Ptychoparella prolifica Resser = *Ptychoparella? prolifica* Resser. The cranidia representing this species show many features in common with the genus, but the specimens occur distinctly distorted in a crumbly siltstone and on most it appears as if the palpebral lobes were somewhat smaller and nearer the center of the glabella than in the genotype.

Ptychoparella teucer (Billings). USNM 111601, casts of the type material, NMC 431, indicate that the holotype cranidium is unidentifiable because of its fragmentary condition.

Ptychoparella vermontensis Resser = *Ptychoparella? vermontensis* Resser. The two figured cranidia are sandstone molds that differ from the genotype in several features, as, (1) somewhat smaller palpebral lobes, (2) glabella conical with nearly straight front and convexity highest posteriorly, and (3) a median inbend of the marginal furrow. The trend is in the direction of *Antagmus* but it does not fit that genus either.

Ptychoparella vulcana (Billings). USNM 111596, casts of the type cranidium NMC 432, indicate that it is too fragmentary for either generic or specific identification.

[1] National Museum of Canada.

ANALYSIS OF PLAGIURA RESSER (1935, p. 42)

Genotype, *Plagiura cercops* (Walcott), whose cotypes are UNSM 64377–64381.

Cranidium:

1. Palpebral lobes small, well forward on anterior one-third line of glabella.
2. Glabella conical with rounded front; regular convexity; three pairs of weak glabellar furrows.
3. Fixed cheeks somewhat less than one-half width of glabella, but not one-third.
4. Fixed cheeks downsloping.
5. Posterolateral limb starting on midline of glabella, length the same or a little longer than the occipital ring.
6. A frontal limb, a frontal border, a nearly straight weak marginal furrow.

Pygidium

1. Wide-transverse in outline.
2. Pleural lobes slightly narrower than axial, narrow marginal furrow, narrow marginal border.
3. Axial lobe heavy, subquadrate in outline, extending clear to border, three segments and a wide terminal portion.

The described species that adhere to these generic features are:

Plagiura cercops (Walcott).

Plagiurella cleadas (Walcott). The type cranidium of this species and several associated cranidia are all smaller than the smallest cranidium of *P. cercops* (Walcott), but they all have the same generic features. They differ from the genotype in having the glabella somewhat more convex, with the glabellar furrows stronger; the frontal border convex; and the posterolateral limb just a little shorter in proportion to the occipital ring.

ANALYSIS OF PLAGIURELLA RESSER (1937a, p. 22)

Genotype, *Plagiurella cleadas* (Walcott), whose holotype is USNM 64382.

1. Palpebral lobes small, well forward on anterior one-third line of glabella.
2. Glabella conical with rounded front; regular convexity; three pairs of clear glabellar furrows.

3. Fixed cheeks a little less than one-half width of glabella.
4. Fixed cheeks downsloping.
5. Posterolateral limb large, starting just forward of midline of glabella, same length as the occipital ring.
6. A frontal limb, a frontal border, a straight marginal furrow.

Plagiurella cleadas (Walcott) exhibits the same diagnostic generic features as *Plagiura cercops* (Walcott) and differs from that species only in three minor features which I regard as of valid specific value. *Plagiurella* Resser 1937 is therefore a synonym of *Plagiura* Resser 1935.

ANALYSIS OF PERIOMMA RESSER (1937, P. 53)

Genotype, *Periomma typicalis* Resser = *Ptychoparia vulcana* Walcott not Billings, whose holotype is USNM 15437.

1. Palpebral lobes small, situated one-third the length of the glabella from the anterior end.
2. Glabella short, conical but strongly tapered; convexity downsloping very steeply from posterior; three pairs of faint arcuate glabellar furrows.
3. Fixed cheeks same width as glabella on midline.
4. Fixed cheeks elevated.
5. Posterolateral limb starting one-third the length of the glabella from the posterior end, same length as occipital ring
6. A frontal limb, a frontal border, a deep slightly curved marginal furrow, a median swelling originating in furrow may expand onto limb and border.

The described species that adhere to these generic features are:

Periomma typicalis Resser.

Periomma cilles (Walcott). Position somewhat doubtful due to preservation of type cranidium. The elevated cheeks and palpebral lobes are broken off so that features 1 and 3 can only be estimated, but in all other features it agrees with *Periomma.*

Periomma cloudi Kindle, a valid species.

Periomma walcotti Resser, a valid species.

DISPOSITION OF OTHER SPECIES OF PERIOMMA

Periomma alabamensis Resser. Although the preservation of the type material of this species is poor, enough can be determined to indicate that it definitely does not belong to *Periomma.* It was found, however, that it exhibited the same set of generic characters as occurs on the cranidium of *Kochina? lux* (Walcott) and a manuscript species in the Mt. Whyte formation at Mount Thompson, Bow Lake, Alberta, which Resser had referred to *Periomma.* The set of features characterizing this group is given below, but a new genus is not described at this time because more material should be available.

1. Palpebral lobes small, very slightly back of midline of glabella.
2. Glabella conical with rounded front; regular convexity; three pairs of short faint glabellar furrows.
3. Fixed cheeks slightly less than width of glabella on midline.
4. Fixed cheeks horizontal.
5. Posterolateral limb a little shorter than occipital ring.
6. A frontal limb, a frontal border expanding posteriorly on median line, causing a median inbend of the marginal furrow.

ANALYSIS OF PERIOMMELLA RESSER (1938, P. 93)

Genotype, *Periommella yorkensis* Resser, whose holotype is USNM 65002.

1. Palpebral lobes small, lying below upper surface of fixed cheek, situated one-third the length of the glabella from the anterior end.
2. Glabella short, conical and strongly tapered with nearly straight front; convexity downsloping steeply from posterior; three pairs of short faint glabellar furrows.
3. Fixed cheeks twice width of glabella.
4. Fixed cheeks elevated with outer edge rolled down vertically.
5. Posterolateral limb starting on posterior one-third of glabella, somewhat longer than occipital ring
6. A frontal limb, very steep at sides, a frontal border, a slightly curved marginal furrow, a median swelling originating in furrow expands onto the frontal limb

The unusual structure of the fixed cheeks, frontal limb, and position of the palpebral lobes suggests that this genus is not really closely related to *Periomma.* The genotype material in the Kinzer shale is so poorly preserved that it is difficult to be certain of all the features, but well-preserved limestone cranidia obtained by Dr. Rasetti from the boulders in the Sillery clearly demonstrate the diagnostic features and the validity of the genus.

The described species that adhere to these generic features are:

Periommella yorkensis Resser.

Periommella roddyi Resser. This species is represented not only by the two types but also by many duplicate specimens. While the crumbly shale preservation is not good, the strongly arched preglabellar area appears to be a distinctive and valid specific feature.

ANALYSIS OF PROLIOSTRACUS POULSEN (1932, p. 48)

Genotype, *Proliostracus strenuelliformis* Poulsen, whose holotype is in Copenhagen Min. Mus. Measurements taken on casts of holotype, USNM 93005.

1. Palpebral lobe nearly medium, slightly forward of midline of glabella
2. Glabella conical with truncate (somewhat squared) front; convexity regular with steep front; four pairs of short distinct glabellar furrows.
3. Fixed cheeks two-thirds width of glabella.
4. Fixed cheeks upsloping.
5. Posterolateral limb starting on posterior one-third of glabella, same length as the occipital ring
6. A frontal limb, a frontal border, a curved marginal furrow of which the median part is very faint due to a median uparching of the preglabellar area.

The described species that adhere to these generic features are:

Proliostracus strenuelliformis Poulsen.

Proliostracus rosenkrantzi Poulsen.

Proliostracus liostracoides Poulsen. Somewhat doubtful as shape of glabella and poor development of glabellar furrows seem wrong.

Proliostracus noe-nygaardi Poulsen.

DISPOSITION OF OTHER SPECIES OF PROLIOSTRACUS

Resser (1938) described two species of *Proliostracus* from the Shady dolomite near Austinville, Virginia, The first, *P. goodwini* Resser, is represented by a number of well-preserved limestone cranidia. The holotype is worn and shows the inner punctate surface, but several duplicate cranidia show the outer surface to be granulated. The second species, *P. granulatus* Resser, was established on a single broken and crushed cranidium having the outer granulated surface well preserved, and it is not specifically distinct from *P. goodwini* Resser. Only the one species is here recognized from this locality.

Analysis of the type cranidia, USNM 94740, of *Proliostracus goodwini* Resser gives the following set of generic characters:

1. Palpebral lobes small, just slightly back of midline of glabella.
2. Glabella broadly conical with straight front; convexity highest posteriorly, sloping gently down anteriorly; three pairs of short glabellar furrows.
3. Fixed cheeks approximately one-half width of glabella.
4. Fixed cheeks slightly downsloping
5. Posterolateral limb starting on posterior one-third of glabella, length slightly less than the occipital ring.
6. A frontal limb, a frontal border expanding posteriorly on median line, causing a median inbend of the marginal furrow.

The generic features indicate that rather than belonging to *Proliostracus* this species is actually very close to the new genus *Crassifimbra*, the main differences being in the more broadly conical glabella and the slightly more posterior position of the palpebral lobes. It is also close to *Ptychoparella* but differs in the smaller palpebral lobes and their position and in the median inbend of marginal furrow.

ANALYSIS OF BONNIA WALCOTT (1916, p. 325)

Resser (1936) made a detailed review of the genus *Bonnia* and at the time named a number of new species. Reexamination of the *Bonnia* material in order to determine the diagnostic generic features brought to light three mistakes in Resser's diagnosis of the genus, and, in my opinion, a most unnecessary duplication of species. Those specimens of which the types are in the National Museum of Canada are represented at the United States National Museum by labeled plaster casts.

Genotype, *Bonnia parvula* (Billings), whose type is NMC 433. Measurements taken on casts in the United States National Museum.

Cranidium:

1. Palpebral lobes medium size, back of midline of glabella but not quite as far back as one-third.
2. Glabella either parallel-sided or expanding slowly to a broad front; regular convexity; first two pairs of glabellar furrows often obsolete, posterior pair sometimes well defined; ocular ridge obsolete in about one-half the species.

3. Fixed cheeks approximately one-half (may be a little more) width of glabella.
4. Fixed cheeks horizontal or very slightly downsloping.
5. Posterolateral limbs slightly less than length of occipital ring.
6. No frontal limb, a convex frontal border, marginal furrow at sides only.

Pygidium:

1. Nearly semicircular in outline, 1, 2 or 3 pairs of anterior marginal spines.
2. Pleural lobes same width as axial lobe, a narrow marginal furrow, a narrow but distinct marginal border.
3. Axial lobe of medium width, cylindrical in shape, extending to border, three clear, one faint segment and a terminal portion.

The following species and their synonyms adhere to these generic features:

Bonnia parvula (Billings). The holotype cranidium is a poor dolomite mold. *Bonnia westoni* Resser, *B. billingsi* Resser and *B. matthewi* Resser are all synonyms of *B. parvula* (Billings), as they differ from the holotype in details largely attributable to preservation. The cranidium of *B. matthewi* Resser shows the appearance of the unweathered outer surface.

Bonnia senecta (Billings). A valid species.

Bonnia brennus (Walcott). A valid species. *B. quebecensis* Resser, USNM 62736, is a synonym.

Bonnia bubaris (Walcott). A valid species, whose holotype cranidium, USNM 62734 has an elevated glabella, a longer occipital spine and a completely granulated surface.

Bonnia busa (Walcott). A valid species. The holotype, USNM 62773 has the glabella slightly tapered anteriorly and a wide flatter border.

Bonnia bicensis Resser. A valid species. The holotype, USNM 62735, has a very small occipital spine, and the anterior portion of the glabella is crossed by ridges while the posterior part is granulated.

Bonnia capito (Walcott). USNM 62746.The preservation of the Kinzer specimens as poor shale molds with every conceivable kind of distortion makes it very difficult to determine true specific features, but it seems that both *B. wanneri* Resser and *B. tumifrons* Resser are synonyms of *B. capito* (Walcott). The pygidia of *B. capito* figured by Walcott appear to have no lateral spines, but in the type lot there is a pygidium with one pair of spines, whereas in the material of *B. tumifrons* Resser most of the pygidia show no marginal spines due to the same poor preservation as in *B. capito* (Walcott) and one pygidium was found definitely showing two pairs of spines. The border of most of the pygidia assigned to the two species is just too worn to show the spines.

B. swantonensis Resser. A valid species, but cranidium is squeezed in an antero-posterior direction. *B. lata* Resser is a synonym —cranidium not distorted. *B. vermontensis* Resser is a synonym—cranidium squeezed laterally.

Bonnia tenuis Resser. A valid pygidium but may belong to a described cranidium.

Bonnia crassa Resser. A valid species.

Bonnia tensa Resser. A valid species. The cranidia of *B. tensa* and *B. crassa* should be restudied with those referred by Resser to *Bonniella tumida* Resser and *Bonniella bracteata* Resser. They all occur in the same locality and I cannot distinguish them from the *Bonnia*. cranidia. None of the distinctive *Bonniella* pygidia is associated with them by Resser.

Bonnia fieldensis (Walcott). A valid species.

Bonnia columbensis Resser. A valid species.

Bonnia sola Resser and Howell. A crushed pygidium too poorly preserved for specific identification.

DISPOSITION OF OTHER SPECIES OF BONNIA

Bonnia clavata (Walcott)—The single crushed small cranidium is considered an immature specimen of the same species as *B. salemensis* Resser, and both specimens agree in all features with the Middle Cambrian *Bonnaspis*. *Bonnia salemensis* Resser is a synonym.

DESCRIPTION OF NEW GENERA

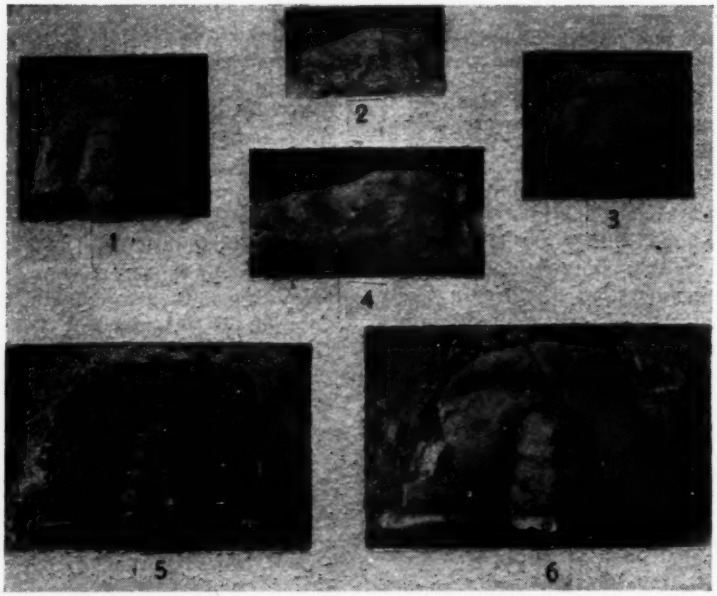
Genus PIAZIELLA Lochman, n. gen.

Figures 4–6

Ptychoparia pia Walcott, assigned to *Antagmus*, is characterized by the following combination of generic features:

1. Palpebral lobes small, somewhat back of midline of glabella but in front of posterior third.

2. Glabella broadly conical, regular convexity; three pairs of strong, medium-length glabellar furrows.
3. Fixed cheeks three-fourths width of glabella on midline.
4. Fixed cheeks horizontal or very slightly downsloping.
5. Posterolateral limb one and one-third times as long as the occipital ring.



FIGS. *1–3—Crassifimbra walcotti* (Resser). *1, 2*, Holotype, dorsal and side views of cranidium, USNM 61642, ×5. *3*, Hypotype, dorsal view of smaller well-preserved cranidium, USNM 61642a, ×5. Both USNM locality 30. (p. 71)

4–6—Piasiella pia (Walcott). *4, 6*, Holotype, side and dorsal views of cranidium, USNM 64391; ×3. *5*, Hypotype, side and dorsal views of somewhat weathered cranidium showing complete posterolateral limbs, USNM 64391a, ×2. Both USNM locality 35f. (p. 69)

6. A frontal limb, a frontal border expanding posteriorly on median line, causing a median inbend of the marginal furrow.

This combination has not been found in any described genus. The features are so definite that they merit designation as a new genus, which may be described as follows:

Cranidium subquadrate, wider than long; glabella conical with slightly rounded front, convexity moderate, regular; three pairs of distinct glabellar furrows, anterior pair short, nearly straight, second and third pairs longer and arcuate; dorsal furrow of medium width, clear along sides, shallower across front; occipital furrow narrow, distinct, deeper at sides; occipital ring of medium width, slightly convex; frontal limb of medium width; marginal furrow narrow, with slight median inbend; frontal border expanding somewhat on median line; anterior margin rounded. Fixed cheeks three-fourths the width of glabella, very slightly downsloping; palpebral lobes small, situated on midline through glabella; palpebral furrow narrow, shallow; ocular ridge narrow, distinct, curved; posterolateral limb one and one-third times as long as occipital ring, of medium width, crossed by a broad, deep intramarginal furrow. Free cheek not known. Facial suture cutting anterior margin far out at sides, curving out to marginal furrow, then running straight back and in to and curving around palpebral lobes; thence running straight out and then curving back to cut posterior margin. Outer surface of test finely granulated.

Thorax and pygidium not known.

Genotype, *Ptychoparia pia* Walcott (1917, p. 93).

Genus CRASSIFIMBRA Lochman, n. gen.
Figures 1–3

The combination of generic features that characterize the cranidia of *Onchocephalus walcotti* Resser (1937a, p. 21), *Ptychoparia cuneas* Walcott (1917, p. 87), *P. cleon* Walcott (1917, p. 84), and *Antagmus arizonaensis* Resser is different from that of any described Lower Cambrian genus. The features are as follows:

1. Palpebral lobes small, on midline of glabella.
2. Glabella broadly conical with rounded corners and straight front; convexity highest posteriorly, sloping down to nearly flat anteriorly; four pairs of short, distinct glabellar furrows.
3. Fixed cheek one-half the width of the glabella on midline.
4. Fixed cheeks downsloping.
5. Posterolateral limbs two-thirds the length of the occipital ring.
6. A frontal limb, a frontal border, a slight median inbend of the marginal furrow.

A formal diagnosis of *Crassifimbra* follows:

Cranidium quadrate; glabella broadly conical with nearly straight front; convexity low, highest posteriorly, sloping to nearly flat anteriorly; four pairs of glabellar furrows, first pair small pits opposite posterior edge of ocular ridge, second, third, and fourth pairs short, shallow, slightly arcuate; dorsal furrow narrow, shallow; occipital furrow narrow, well defined at sides; occipital ring narrow, triangular, may have a small median posterior node; frontal limb of median width; marginal furrow narrow, shallow, with a slight median inbend; frontal border of medium width; anterior margin smoothly curved. Fixed cheeks one-half width of glabella, downsloping; palpebral lobes small, situated on midline of glabella; palpebral furrow very faint; ocular ridge narrow, faint, slightly curved; posterolateral limb of medium width, two-thirds length of occipital ring, crossed by a narrow, shallow intramarginal furrow. Free cheek not known. Facial suture cutting anterior margin on line with dorsal furrow, curving out and back to marginal furrow, then running straight back to and curving around palpebral lobes, thence curving down and back abruptly to posterior margin. Outer surface of test apparently smooth.

Thorax and pygidium not known.

Genotype, *Onchocephalus walcotti* Resser.

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REFERENCES

LOCHMAN, C. and DUNCAN, D., 1944, Early Upper Cambrian faunas of central Montana: Geol. Soc. America Special Papers 54.

POULSEN, CHR., 1927, The Cambrian, Ozarkian and Canadian faunas of northwest Greenland: Meddelelser om Grønland, Bd. 70, Nr. 2 pp. 233–343.

——, 1932. The Lower Cambrian faunas of east Greenland: Meddelelser om Grønland, Bd. 87, Nr. 6.

RESSER, C. E., 1935, Nomenclature of some Cambrian trilobites: Smithsonian Misc. Coll., vol. 93, no. 5.

——, 1936, Second contribution to nomenclature of Cambrian trilobites: Smithsonian Misc. Coll., vol. 95, no. 4.

——, 1937, Elkanah Billings' Lower Cambrian trilobites and associated species: Jour. Paleontology, vol. 11, no. 1, pp. 43–54.

——, 1937a, Third contribution to nomenclature of Cambrian trilobites: Smithsonian Misc. Coll., vol. 95, no. 22.

———, 1938, Cambrian system (restricted) of the southern Appalachians: Geol. Soc. America Special Papers 15.

WALCOTT, C. D., 1916, Cambrian trilobites: Smithsonian Misc. Coll., vol. 64, no. 5.

——, 1917, Fauna of the Mount Whyte formation: Smithsonian Misc. Coll., vol. 67, no. 3.

JOURNAL OF PALEONTOLOGY, VOL. 21, NO. 1, PP. 72–76, 1 TEXT FIG., JANUARY 1947

TERMINOLOGY FOR DESCRIBING CAMBRIAN TRILOBITES

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G. O. RAASCH,[4] AND F. RASETTI[5]

ABSTRACT—Several different terms have been applied by students of Cambrian trilobites to each of about 10 features of the cephalon and to several features of the pygidium. As uniformity in terminology is most desirable, a common set of terms for the various parts of the Cambrian trilobite carapace and a standard pattern for writing a specific description are here proposed. For each of the recommended terms there is given a list of the synonyms and the authors who have used them. A definition of each term as it is proposed that it should henceforth be used and a labelled diagram of a trilobite carapace are presented to insure complete clarity of the terms.

DURING the past 50 years a number of authors have had occasion to describe Cambrian trilobites. Although little or no attempt was made by these authors to define the terms each used for the different parts of the trilobite carapace, nevertheless, there has been a general uniformity in the use of most of the terms. (Warburg, 1925; Twenhofel and Shrock, 1935; Shimer and Shrock, 1944.) For about 10 parts of the cephalon and for several parts of the pygidium, however, there has been wide and unnecessary variation in the terminology employed. It is the purpose of this paper to urge the use of a more uniform terminology in the future.

We recommend at this time a definite pattern for a concise, yet clear and complete, specific description of a trilobite carapace, and we urge that the terminology used in this description be uniform. After a consideration of the various methods and the different terms that have been in general usage, we have compiled the set of terms shown in figure 1 and a pattern for a description. The parts of the carapace recognized and the terms here proposed are found to be adequate for the description of most Cambrian trilobites because the carapace of the average trilobite of that period is relatively simple and generalized. However, for post-Cambrian trilobites, more terms may be needed to describe the greater detail and complexity of their carapaces. Among Cambrian trilobites the proposed terminology is considered adequate for all members of the Olenellidae and for most known Opisthoparia and Proparia of that period; but for all blind trilobites, however classified, it is not adequate, as several different terms are needed for parts of the cephalon. These forms have not been specifically considered in this paper.

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PATTERN FOR THE DESCRIPTION

We recommend that a concise, yet clear and complete, description should be written for each particular species, and especially that the author of a species should not assume that his readers will know after a glance at the illustrations, all the details of the species as well as he does. In the past many specific descriptions have been made so short and incomplete that they have proved quite inadequate for recognition. It is proposed that descriptions of Cambrian trilobites be written in a regular sequential order, so that only descriptive phrases are needed. The proposed order is a logical one which has already been in general use by several of us.

I. Proportions of the complete dorsal carapace (when present).

II. Cephalon:
  1. Cranidium (describe parts in following order):
     Glabella and occipital region.
     Area in front of Glabella, working forward to anterior margin.
     Fixed cheek area.
     Posterior limb.
  2. Free cheek.
  3. Course of facial suture.
  4. Hypostoma and other ventral parts.

III. Thorax:
1. Axis.
2. Pleural lobes.
3. Ventral parts.

IV. Pygidium:
1. Axis.
2. Pleural lobes.
3. Border.
4. Doublure and other ventral parts.

TERMINOLOGY

In the diagram (fig. 1) are presented the terms recommended for use in writing the descriptions. In order to facilitate the reading and understanding of the descriptions already published by Cambrian students, we list below under each of the recommended terms the common synonyms and the authors who have used them. Furthermore, to insure complete clarity of the recommended terms, a list of definitions for each term is added.

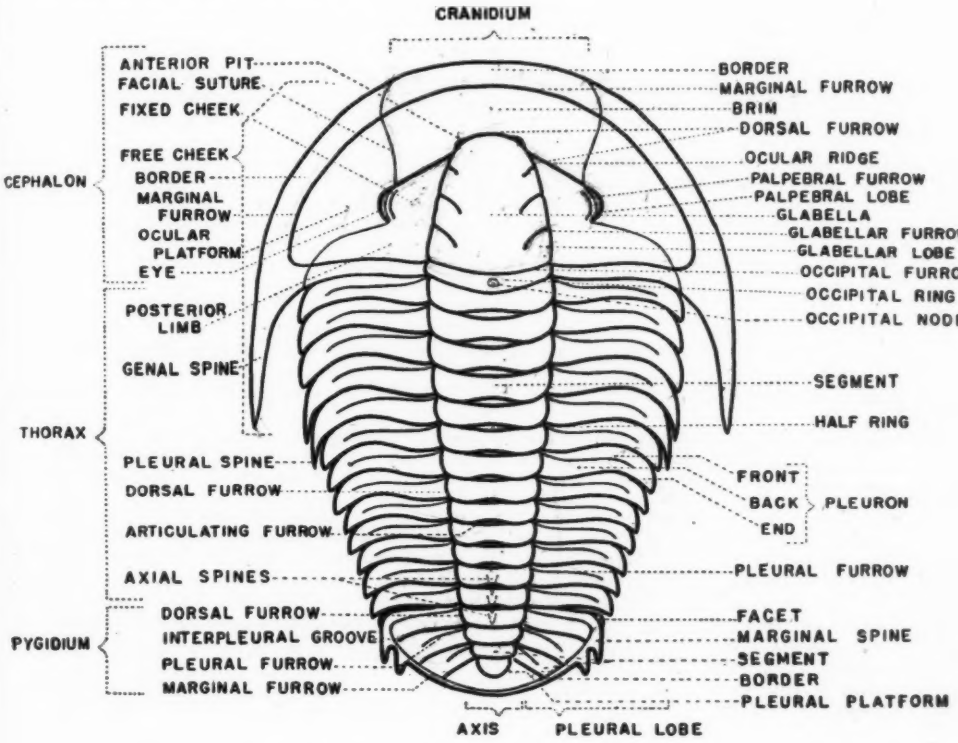

FIG. 1—Terminology of Cambrian trilobites.

SYNONYMS

I. For the cranidium:
1. Border = anterior border (Warburg), rim (Bridge, Resser, Raymond, Howell, Rasetti, Deiss, Poulsen), anterior rim (Whitehouse), frontal border (Walcott, Lochman), brim (Howell).
2. Marginal furrow = front furrow and posterior marginal furrow (Warburg), transverse furrow and intramarginal furrow (Walcott, Lochman), frontal furrow and posterior marginal furrow (Poulsen).
3. Brim = frontal limb (Walcott, Lochman), preglabellar area (Deiss, Rasetti, Resser, Warburg), preglabellar field (Poulsen, Westergaard), preglabellar field and anterior limb (Whitehouse). The brim (of Resser) sometimes means the entire area in front of the glabella to the anterior margin; the brim (of Diess, Rasetti) always has this meaning.
4. Dorsal furrow = preglabellar and axial furrow (Warburg), axial furrow (Twenhofel and Shrock, many authors), circumglabellar furrow or furrows (Poulsen, Bridge, Raymond).

5. Ocular ridge = eye ridge (Warburg, Deiss), eye line (Resser, Bridge, Howell), ocular fillet (Howell).
6. Palpebral lobe = eye lobe (Deiss).
7. Facial suture as defined here is understood to include both the anterior branch and the posterior branch of the dorsal suture (Warburg) and the marginal portion along the front of the cranidium.
8. Occipital furrow = nuchal or neck furrow (Raymond, Howell).
9. Occipital ring = nuchal ring (Raymond), neck ring (Resser, Howell, Whitehouse), occipital segment (Rasetti).
10. Posterior limb = posterolateral limb (Walcott, Lochman, Rasetti, Whitehouse, Westergaard), posterior lateral lobe (Bridge).
11. Fixed cheeks = fixigenes (Resser, Rasetti).

II. For the free cheek:

1. Free cheeks = libragenes (Resser, Rasetti).
2. Border = lateral border (Warburg), brim (Howell).
3. Marginal furrow = lateral marginal furrow (Warburg).

III. For the thorax a much simpler terminology is used than that proposed by Warburg. It is quite adequate for Cambrian trilobites, as for the vast majority of the species the thorax is not yet known.

IV. For the pygidium:

1. Axis = axial lobe (Deiss, Walcott, Lochman, Raymond).
2. Segment = axial ring (Raymond), annulation (Bridge).
3. Interpleural groove = rib furrow (Warburg), furrow (Lochman), pleural furrow (Resser occasionally).
4. Border = marginal border (Lochman), brim (Howell).

DEFINITIONS

I. Parts of the cephalon:

Cranidium = the central portion of the cephalon, bounded laterally in most Opisthoparia and Proparia by the facial sutures.

Border = that portion of the cranidium lying between the anterior margin and the marginal furrow.

Marginal furrow = a usually curved groove lying at varying distances in front of the anterior end of the glabella and extending from facial suture to facial suture. Even when obsolete its position at the facial suture can be determined, as at this point the anterior portion of the facial suture apparently always changes its direction.

Brim = that portion of the cranidium lying between the marginal furrow (which defines it anteriorly) and the front of the glabella and ocular ridges (which define it posteriorly) and bounded laterally by the facial sutures. If the ocular ridges are obsolete, the posterior boundary is an imaginary line running diagonally from the front of the palpebral lobes to the anterior corners of the glabella. When the marginal furrow intercepts the dorsal furrow, the brim may be present only on the sides in front of the fixed cheeks. (It should be noted that the side areas of the brim in front of the ocular ridges have in the past frequently been considered as a part of the fixed cheeks.)

Dorsal furrow = a groove outlining the glabella; extending from the posterior edge of the cephalon, delimiting the lateral sides of the occipital ring, and running along both sides of the glabella and around the front.

Anterior pit = a small circular or oval depression occurring occasionally in the dorsal furrow at or near the anterolateral corners of the glabella.

Facial suture = line of junction between the cranidium and free cheek, usually open at ecdysis. It is bilaterally symmetrical, crosses the dorsal surface of the cephalon, and continues across the front of the cranidium in a marginal or submarginal position. It always lies along the dorsal edge of the eye, but its course anterior and posterior to the eye is variable.

Ocular ridge = a narrow elevation extending from the anterior end of the eye to, or just back of, the anterolateral corners of the glabella.

Fixed cheek = the area lying back of the ocular ridge and anterior to an imaginary line extending from the posterior end of the eye diagonally backward to the junction of the dorsal and occipital furrows. It is bounded laterally on its inner side by the dorsal furrow and on its outer side by the facial suture immediately above the eye.

Palpebral lobe = the slightly raised, generally somewhat curved outer edge of the fixed cheek which lies immediately above (dorsal to) the eye.

Palpebral furrow = a somewhat curved groove separating the palpebral lobe from the larger inner portion of the fixed cheek.

Glabella = axial portion of the cranidium, bounded by the dorsal furrows on the sides and front and by the occipital furrow posteriorly.

Glabellar furrows = narrow, generally curved grooves extending inward on each side of the glabella from the dorsal furrow part of the way across the glabella; occur in bilaterally symmetrical pairs, the inner ends of which sometimes meet to form a continuous furrow across the glabella.

Glabellar lobes = the areas on the glabella located between successive pairs of glabellar furrows; cannot be distinguished if the furrows are obsolete.

Occipital furrow = a usually prominent transverse groove running from dorsal furrow to dorsal furrow to form the posterior boundary of the glabella; sometimes obsolete.

Occipital ring = the axial portion of the most posterior segment of the cephalon, back of the occipital furrow.

Occipital node = a tubercle of variable size located on the median dorsal surface of the occipital ring. If elongated, it becomes an occipital spine, which may be long or short, and may lie in any position from horizontal to nearly vertical.

Occipital spine = see occipital node.

Posterior limb = the area of the cranidium lying posterior to the back end of the fixed cheek and extending to the posterior margin of the cranidium. It is bounded on the inside by the dorsal furrow and on the outside by the facial suture. It is crossed by the marginal furrow and is thus divided into an anterior portion and a posterior border.

Free cheeks = the lateral portions of the cephalon lying outside the facial sutures.

Border = that part of the free cheek lying outside the marginal furrow.

Marginal furrow = a groove (a continuation backward of the marginal furrow of the cranidium) running outward and backward across the free cheek to the posterior corner of the cheek and then curving inward towards the glabella to the facial suture, beyond which it continues across the posterior limb of the cranidium to the dorsal furrow.

Ocular platform = a roughly triangular inner area of the free cheek bounded on the outside by the marginal furrow and on the inner sides by the facial suture and the eye.

Eye = a curved band bearing eye lenses (or facets) covered by a complete cornea (holochroal). The band is widest through the center, tapers at each end, and lies in a vertical or steeply slanting position.

Genal angle = the posterolateral corner of the cephalon.

Genal spine = a posterior extension of the border and doublure at the genal angle to form a hollow spine.

II. Parts of the thorax:

Axis = the longitudinal central portion of the thorax bounded on each side by a longitudinal groove, the dorsal furrow.

Dorsal furrow = a bilaterally symmetrical longitudinal groove running the full length of the thorax on each side of the axis.

Pleural lobes = the longitudinal lateral portions of the thorax.

Pleuron = the lateral part of each segment of the thorax.

Pleural spine = a posteriorly directed extension of the end of the pleuron.

Pleural furrow = a groove extending transversely backward across the pleuron from the dorsal furrow to near the end of the pleuron.

Segment = a transverse division of the thorax consisting of two pleura and a central axial portion.

Half ring = an anterior extension of the segment which bends downward to pass under the posterior edge of the segment just in front of it.

Articulating furrow = the well-defined transverse groove between the main portion of the axial segment and the half ring.

Axial spine = a projection of variable length, size and direction on the median dorsal surface of the axial segment. If only of tubercle size it is called an axial node.

III. Parts of the pygidium:

Axis = the longitudinal central part of the pygidium bounded on each side and at the posterior end by a groove, the dorsal furrow.

Dorsal furrow = a bilaterally symmetrical groove running along the sides and curving around the end of the axis.

Pleural lobes = the longitudinal lateral portions of the pygidium.

Segment = a transverse division of the pygidium consisting of a central axial portion and a pleural portion on each side.

Pleural platform = the roughly triangular lateral part of the pygidium, bounded on the inside by the dorsal furrow and on the outside by the marginal furrow.

Interpleural groove = a transverse depression extending from the dorsal furrow across the pleural platform and border to the outer margin. It indicates the position of the fused segments of the pleural lobes of the pygidium.

Pleural furrow = a groove extending transversely across each fused segment of the pleural lobes. It may stop before, at or beyond the marginal furrow.

Marginal furrow = a groove encircling the pygidium along the outer edge of the triangular pleural platform.
Border = the portion of the pygidium lying outside the marginal furrow.
Facet = a small triangular area situated at the anterolateral corners of the pygidium and lying at a depressed angle to the surface of the anterior segment.
Axial spine = a projection of variable length, size and direction on the median dorsal surface of the axial segment. If only of tubercle size it is called an axial node.
Marginal spine = a posteriorly directed extension of the border and doublure of a segment to form a hollow spine.

IV. Parts of the ventral surface (not illustrated):
Doublure = a continuation of the hard dorsal carapace onto the ventral surface as a narrow rim or shelf, which completely encircles the cephalon, lies under the posterior part of the axis of each thoracic segment and the ends of the pleura, and continues under the border of the pygidium.
Hypostoma = a small oval, triangular or rectangular plate lying anterior to the mouth opening on the ventral surface.
Metastoma = a very small oval or square plate lying posterior to the mouth opening on the ventral surface. Very rarely observed in Cambrian trilobites.

REFERENCES

SHIMER, H. W. and SHROCK, R. R., 1944, Index fossils of North America.
TWENHOFEL, W. H. and SHROCK, R. R., 1935 Invertebrate paleontology.
WARBURG, ELSA, 1925, The trilobites of the *Leptaena* limestone in Dalarne: Geological Institute Upsala Bull., vol. 17, p. 2.

REMOPLEURIDES SINCLAIRI, NEW NAME

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In 1936 we described an Ordovician trilobite from Percé, Quebec as *Remopleurides striatus*. G. Winston Sinclair has recently brought to our attention that F. R. C. Reed in 1935 referred Endo's *Robergia striata* (1932) to the genus *Remopleurides*. Endo's illustration is certainly that of a *Remopleurides* and so a new name must be provided for our species. We propose to call it *Remopleurides sinclairi* Cooper and Kindle.

REFERENCES

COOPER, G. ARTHUR and KINDLE, CECIL H., 1936, New Brachiopods and trilobites from the upper Ordovician of Percé, Quebec: Jour. Paleontology, vol. 10, p. 362, pl. 52, fig. 32, 33, 40.
ENDO, RUIJI, 1932, U. S. Nat. Mus. Bull. 164, p. 109, pl. 38, fig. 3.
REED, F. R. C., 1935, Girvan trilobites, supplement 3: Palaeontographical Society, p. 10.

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PALEOECOLOGICAL IMPORT OF CERTAIN RELATIONSHIPS OF MARINE ANIMALS TO SALINITY

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IN RECENT years paleontologists have been trying more than in the past to learn how fossil organisms lived in relation to each other and to the environment. This has forced them to draw upon the data of the other biological sciences, especially ecology. In searching ecology for information relevant to their problems, paleontologists make the assumption that the general interrelationships of organisms and the environment have been much the same throughout the ages. The fundamental requirements of life are rather sharply limited, and no doubt the assumption is justified.

Certain relationships of marine animals, chiefly distribution relative to salinity, which I have studied in recent years, may interest paleontologists. The papers are scattered and little or no reference is made to the conclusions that paleontologists might draw and utilize in their studies. In this paper such conclusions will be presented.

I am indebted to Dr. W. Armstrong Price, Consulting Geologist of Corpus Christi, Texas for criticism of this paper.

Many marine animals, especially fishes, are euryhalin, that is they may migrate from sea water to fresh water and *vice versa*. Today an association of several marine fishes may be found in pure fresh water at Homassassa Springs, Florida. Furthermore, probably a greater proportion of the ancient aquatic animals were euryhalin than is the case today. This conclusion may be drawn from two facts. (1) The seas have in general been growing saltier and therefore it is becoming more difficult physiologically for animals to change from sea water to fresh water or the reverse. (2) It has been shown (Gunter, 1942) that of the present euryhalin fishes of North and Middle America a greater proportion of the lower, less specialized species, and a smaller proportion of the higher, more recent types, are euryhalin. Since the lower fishes are most similar to the ancient fishes it seems reasonable to conclude that the ancient fishes were more euryhalin on the whole than the modern fishes. This means, as has been pointed out before (Gunter, 1938), that the finding of a fossil fish in a fresh-water deposit is no certification that it was a fresh-water species. Since it has been shown (Gunter, MS 1) that marine fishes entering fresh water are generally the small ones or young, and there is reason to believe the same holds true of invertebrates, the situation becomes even more doubtul if the fossil is obviously that of a small or young specimen.

Marine animals as a whole are better able to tolerate a lowering of salinity than fresh water animals to tolerate a rise in salinity (Pearse, 1936, Gunter, 1942, 1945), which accounts for the fact that brackish-water, bay, and estuarine faunas are marine and not fresh-water (Pearse, 1936, Gunter, 1945). In North and Middle America the species of marine fishes invading fresh water outnumber the fresh-water species invading sea water by more than nine to one (Gunter, 1942). Therefore, the finding of a fossil fish or other animal in a marine deposit is a good indication that the animal was marine, whereas the finding of a fossil in a fresh-water deposit does not indicate so clearly that the animal was of fresh-water origin.

Although the fauna of bays and estuarine waters is marine, large numbers of marine species can not undergo a lowering of salinity or at least are not found in waters where the salinity is materially lower than sea water. On the other hand, practically all marine animals which tolerate low salinities will tolerate high salinities and are found commonly in highly saline waters (Gunter, 1945). Since there are various degrees of toleration of lowered salinities, species gradually drop out as the salinity gradient

is traversed from higher to lower, from the open seas through the bays to the river mouths (Gunter, 1945). The result is that as the distance covered by a salinity gradient is traveled from lower to higher, from the river mouths to the open seas, it is found that the number of species of animals increases. In short, there is a direct relationship between an increase in salinity and the number of species of animals living in the water (Gunter, 1945). This situation holds along all normal coasts, with normal salinity gradients.[1] It is reasonable to assume that the same correlation between salinity and the number of species of animals living in the water held true in former geological eras. It follows that if a paleontologist working along a marine horizon finds that the number of species of animals increases, it is strong evidence that he is following a salinity gradient.

There have been a few passing observations on certain marine shrimps showing that the young entered less saline waters than the adults (Ehrenbaum, 1890, Viosca, 1920, Havinga, 1930). Weymouth, Lindner and Anderson (1933) found that there was a direct correlation between the size of the commercial shrimp, *Penaeus setiferius* (Linnaeus), and the salinity of the water. Gunter (1945, MS 2) has shown that in general the direct relationship between salinity and size holds true for all motile marine animal inhabiting coastal areas where there is a salinity gradient. The relationship between salinity and size of attached or slightly motile animals has been little worked on, but some observations indicate that such animals are smaller near the lower extreme of their salinity range (Rice 1930, Metcalf 1930, Milne 1940). Milne who worked on sessile organisms on buoys said:

> Generally the organisms become less numerous and smaller towards the lower end of their salinity range, as very obviously shown without measurement by *Laminaria* and *Mytilus*.

[1] The relationship between the number of species of animals and salinity in inland bodies of salt water that are connected to the sea by very narrow channels and which at times become much saltier than sea water, such as the Laguna Madre of the Texas Coast, is unknown. These are special cases.

Laminaria is a brown alga and *Mytilus* is a mussel. Metcalf (1904, 1930) has indicated that certain gastropods living near their upper salinity limit in brine pools are smaller than average size. However, since marine animals are not normally subjected to salinities above their toleration point in ordinary sea water, we are not concerned with that situation. The fact that the relationship between salinity and size of motile and attached animals probably result from the influence of two separate factors, to be discussed in a future paper, is of no importance to the present discussion and can also be ignored. The appearance is the same in both instances.

It follows that if a paleontologist working along a marine horizon finds that the average size of fossil animals increases, it is strong evidence that he is following a former increasing salinity gradient. This second method of determining the presence and direction of a former salinity gradient coupled with the first might be conclusive.

SUMMARY

Ancient animals were probably more euryhalin than those of today, and paleontologists should exercise great care in deciding that a fossil found in a fresh-water deposit is actually a fresh-water species. In general a direct relation exists between an increase in salinity in coastal water and an increase in the number of animal species, as well as an average increase in the size of each species. These facts can be used by paleontologists in detecting the presence and direction of a former salinity gradient where marine fossils are found.

REFERENCES

EHRENBAUM, E., 1890, Zur Naturgeschichte von *Crangon vulgaris:* Deutschen Fischerei-Ver. Beilagen Sektion f. Küsten-und Hochseefischerei Mitt. Berlin.

GUNTER, GORDON, 1938, Notes on the invasion of fresh water by fishes of the Gulf of Mexico, with special reference to the Mississippi-Atchafalaya river system: Copeia for 1938, no. 2, pp. 69–72.

——, 1942, A list of the fishes of the mainland of North and Middle America recorded from both fresh water and sea water: Am. Midland Naturalist, vol. 28, pt. 2, pp. 305–326.

——, 1945, Studies on marine fishes of Texas: Institute Marine Sci. Pub., vol. 1, no. 1, pp. 1–190.

——, (MS 1), The size of marine fishes invading fresh water.
——, (MS 2), Distributions, abundance and seasonal population changes of certain invertebrates of the Texas Coast, with temperature and salinity data.
HAVINGA, B., 1930, Der Granat (*Crangon vulgaris* Fabr.) in den holländischen Gewässern: Conseil Permanent Internat. Explor. Mer Jour. du Counseil, vol. 5, no. 1, pp. 57–87.
MILNE, A., 1940, The ecology of the Tamar estuary, IV. Distribution of the fauna and flora on buoys: Marine Biol. Assoc. Jour., vol. 24, pp. 69–87.
METCALF, Z. P., 1904, *Neritina virginea* var. *minor:* Am. Naturalist, vol. 38, pp. 565–569.
——, 1930, Salinity and size: Science, vol. 72, pp. 526–527.
PEARSE, A. S., 1936, The migrations of animals from sea to land. x+176 pp. Duke Univ. Press., Durham, N. C.
RICE, L., 1930, Peculiarities in the distribution of barnacles in communities and their causes: Puget Sound Biol. Sta. Pub. 7, pp. 249–257.
VIOSCA, PERCY, 1920, Report of the Biologist: Louisiana Dept. Conservation Fourth Bienn. Rept., 1918–1920, pp. 120–130.
WEYMOUTH, FRANK W., MILTON J. LINDNER, and W. W. ANDERSON, 1938, Preliminary report on the life history of the common shrimp, *Penaeus setiferus* (Linn.): Bur. Fish. Bull. vol. 48, pp. 1–25.

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THREE NOMENCLATURAL PROBLEMS IN LIASSIC AMMONOIDEA

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1. ARIETICERAS VS. SEGUENZICERAS

In a recent paper dealing with a Rhaeto-Liassic fauna from the province of Bergamo (Italy), Orlando Vecchia (1945, p. 3) revives Levi's (1896, p. 272) proposal to replace Seguenza's generic name *Arieticeras* by *Seguenziceras* and, consequently, uses the latter name rather than the former, fully unaware of the fact that I had more than thirty years earlier (Haas, 1913, p. 58) proved Levi's argument, that *Arieticeras* was preoccupied as a generic name by Quenstedt, to be entirely unfounded.[1] Vecchia's (1945) appeal to Art. 34 of the International Rules of Zoological Nomenclature is of no avail, since Levi's assumption that *Arieticeras* has been previously used as a generic name for another genus (*Arietites*) has been demonstrated as erroneous.

2. FUCINICERAS VS. HILDOCERATOIDES

In the same paper Vecchia (1945, pp. 7–9) applies the generic name *Hildoceratoides* to several species included by me (Haas, 1913, pp. 75–87) in the subgenus *Fuciniceras* (Haas, 1913),[2] among them *F. lavinianum* (Meneghini), there (p. 77) designated as the type species of *Fuciniceras*. Some search of the Italian literature seems to make it evident that, in so doing, Vecchia merely follows Fucini, who in his monograph on the Taormina fauna left of all the species assigned by me to *Fuciniceras* only *F. meneghinianum* Haas with that genus (Fucini, 1931, p. 107), while referring (Fucini, 1929, pp. 46–50) most of the others, including the type species, *F. lavinianum* (Meneghini), to *Hildoceratoides* Buckman (1919–1921, p. 55, pls. 138A, 218), whose genotype is *H. propeserpentinus* Buckman (1919–1921, pl. 218).

Regardless of nomenclatural rules, this transfer seems entirely unfounded, since *Fuciniceras*, according to the generic diagnosis (Haas, 1913, p. 77), is characterized by coarse falciform ribs that are only little sinuous and somewhat rursiradiate, whereas "the sharp swing backwards of the ribs" (which are less coarse and much more sinuous than in *Fuciniceras*) is considered by Buckman distinctive of his genus *Hildoceratoides*.

[1] This rejection of "*Seguenziceras*" was commended by von Pia (1913, p. 488; 1918, p. 319) and accepted by Meister (1914, p. 558) and others.

[2] See also von Pia, 1913, pp. 488, 493; Meister, 1914, pp. 559–563; Zittel-Broili, 1924, p. 576; Schröder, 1925, pp. 235 ff.; 1927, pp. 45–52, pl. 3, figs. 1–6.

However, if there were not such a wide morphological difference, and if Fucini were right (as he is wrong) in uniting most of the species referred by me to *Fuciniceras* with those for which Buckman established his genus *Hildoceratoides*, then he would still have overlooked the fact that *Fuciniceras*, established in 1913, antedates Buckman's generic name of 1921. Therefore, if the two groups were congeneric, the earlier name *Fuciniceras* would have to be used for both of them and *Hildoceratoides* would be invalid because it would be a synonym of *Fuciniceras*.

In my opinion, however, the differences stated above exclude congenerity between those groups and, for both biological and nomenclatural reasons, the several species referred by me to *Fuciniceras*, but transferred to *Hildoceratoides* by Fucini (and Vecchia), as well as the congeneric species referred to the latter genus by Fucini, are to be left with *Fuciniceras*.

3. Are the Generic (and Subgeneric) Names Established in Fucini's Taormina Monograph Valid?

By way of appendix it might be expedient to examine the validity, under the nomenclatural rules, of the generic (and subgeneric) names created by Fucini in his Taormina monograph. Throughout that monograph, no authors of genera are given,[3] nor is any of those names designated a new name, nor is a generic (subgeneric) diagnosis, or definition, or description given in any case; needless to say that there are no type species designated either. Thus, there cannot be any doubt that under Art. 25 of the Rules, as emended, all the generic names that are published after December 31, 1930, viz. those contained in part 4 (published in 1931), are invalid.[4] However, also the validity of the generic and subgeneric names created in parts 1–3 of that monograph and published prior to January 1, 1931, except that of the monotypic subgenus *Procliviceras* (of *Phylloceras*), may seriously be questioned,[5] since the requirements of Art. 25a "that [the generic] name [has to be] . . . accompanied by an indication, or a definition, or a description" cannot be said to be met under the conditions reported above.

[3] See also Dacqué, 1932, p. 445.

[4] This affects Fucini's following generic names: *Meneghinia*, *Fontanelliceras*, *Seguentia*, *Tauromenia*, *Emaciaticeras*, *Naxensiceras*, *Di-Stefania*, *Trinacrioceras*. *Meneghinia* is, in addition, a homonym (see Nomencl. Zool., vol. III, 1940, p. 101).

References

Buckman, S. S., 1919–1921, Type ammonites, vol. 3. London (Wheldon and Wesley, Ltd.)

Dacqué, E., 1932, Review of Alb. Fucini, Fossili domeriani dei dintorni di Taormina, pts. 1–4: Neues Jahrb. Referate, III, pp. 445–446.

Fucini, A., 1929, Fossili domeriani dei dintorni di Taormina, pt. 3: Palaeontographica italiana, vols. 29–30, pp. 41–77, pls. 4–15, 2 text figs.

——, 1931, *Idem*, pt. 4: *ibid.*, vol. 31 (n. ser., vol. 1), pp. 93–149, pls. 5–21, 2 text figs.

Haas, Otto, 1913, Die Fauna des mittleren: Lias von Ballino in Südtirol, Teil II: Beitr. Paläontologie Österr.-Ungarns u. des Orients, vol. 26, pp. 1–161, pls. 1–7.

Levi, G., 1896, Sui fossili degli strati a *Terebratula aspasia* di M. Calvi presso Campiglia: Soc. geol. italiana, Boll., vol. 15, pp. 262–276, pl. 8.

Meister, Ernst, 1914, Zur Kenntnis der Ammonitenfauna des portugiesischen Lias: Zeitschr. Deutsche geol. Gesell., Band 65, Abt. A, pp. 518–586, pls. 2, 12–15, 10 text figs.

Pia, J. von, 1913, Review of Haas, 1913: Neues Jahrb. 1913, Band 2, pp. 485–493.

——, 1918, Review of O. Saxl, "Über ein Juravorkommen bei Skutari in Albanien:" *idem*, 1918, pp. 318–319.

Schröder, Joachim, 1925, Die jurassischen Fleckenmergel in den bayrischen Alpen: Neues Jahrb. Beil. Band 52, Abt. B, pp. 214–283.

——, 1927, Die Ammoniten der jurassischen Fleckenmergel in den bayrischen Alpen: Palaeontographica, Band 68, pp. 111–232, pls. 7–13; vol. 69, pp. 1–110, pls. 1–4.

Vecchia, Orlando, 1945, Una fauna retico—liassica della sponda occidentale Sebina (Bergamo): Riv. italiana paleontologia, year 51, fasc. 1, pp. 1–13, pl. 1.

Zittel, Karl A. von, 1924, Grundzüge der Paläontologie (Paläzoologie), I Abteilung, Invertebrata. 6th ed., revised by Dr. Ferdinand Broili. Munich and Berlin (R. Oldenbourg).

[5] This affects Fucini's following generic and subgeneric names: *Partschiceras* (subgenus of *Phylloceras*), *Audaxlytoceras* (subgenus of *Lytoceras*), *Bassaniceras*, *Praeleioceras*.

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